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AN 02B-105BB-2

HANDBOOK
SERVICE INSTRUCTIONS

MODELS
J33-A-10A AND -20
AIRCRAFT ENGINES

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1 DECEMBER 1956

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INTRODUCTION

This handbook provides service instructions for model J33-A-10A and -20 turbo-jet engines manufactured by the Allison Division of General Motors Corporation, Indianapolis, Indiana. The instructions cover maintenance and inspection which can be performed by operating units.

Each engine has a dual-entry centrifugal compressor; fourteen through-flow combustion chambers; and a single-stage turbine.

SECTION I SPECIAL SERVICE TOOLS

1-1. GENERAL.

1-2. This section lists by function and numerical order the special tools required for the work described in this handbook. These tools are referred to by the tool group numbers listed in paragraph 1-4.

1-3. Use plastic or rawhide hammer heads—never metal—when driving on any part of the engine. Never lift heavy parts by hand; use a chain or powered hoist and special lifting yokes. Apply pressure or tension evenly to all bearing pushers and pullers. Tighten jack screws and attaching bolts and nuts in small increments on opposite planes.

1-4. SPECIAL SERVICE TOOLS.

<i>Group Number</i>	<i>Application and Name</i>	<i>Tool Number</i>	<i>Figure Number</i>
1.	Accessories and accessories case		
	Drift	2980	2-9
	Expander	2827	2-8
	Expander	2947	2-8
	Expander	2948	2-8
	Gage	3696	2-43
	Gage	6504	2-11
	Fixture	6505	2-11
2.	Air adapter		
	Extension	3613	2-15
	Puller	9074026	2-17
3.	Engine		
	Overhaul stand	2995	2-4
	Transportation stand	3629	2-5

Section I

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<i>Group Number</i>	<i>Application and Name</i>	<i>Tool Number</i>	<i>Figure Number</i>
4. Engine lifting			
	Eye	9074017	2-3, 5-1
	Rear lift bracket.....	2835	2-3
	Sling	9074016	2-3
5. Engine testing			
	Tail pipe and jet nozzle.....	3659	5-56
6. Exhaust cone measurement			
	Gage	2988	5-25
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	Impact puller	3143	2-34
	Pin drift	6009	2-35
12. Turbine coupling			
	Arm	2873-4	5-6
	Locknut wrench and holder.....	2962	5-5
	Lockwasher pliers	3147	5-48
	Plug	2873-5	5-6
	Plug	2873-6	5-6
	Puller	2873	5-6
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	Adjusting nut wrench.....	3634	5-35
	Compressing tool	3615	5-8
	Sliding ring puller.....	2969	5-7

<i>Group Number</i>	<i>Application and Name</i>	<i>Tool Number</i>	<i>Figure Number</i>
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	Blade radial stretch gage.....	3682	2-33
15.	Turbine rotor assembly		
	Compressing tool	3615	5-8
	Lifting eye	2952	5-34
	Locknut wrench	3634	5-35
	Stand	2994	5-34
16.	Turbine rotor disassembly		
	Bearing and oil deflector puller.....	3653	5-12, 5-13
	Compressing tool	3615	5-8
	Guide sleeve	2963	5-9
	Holder	2956	5-11
	Lifting eye	2952	5-34
	Lifting yoke	2973	5-14
	Puller arms	3669	5-13
	Wrench	2955	5-11
17.	Turbine unit		
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	Turbine rotor stand.....	2994	5-34
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	Yoke	9074005	5-17

¹ Jetcal analyzer BH112J and Takcal BH150 are made by the B and H Instrument Company, Fort Worth, Texas.

² This tool is not illustrated.

1-5. NUMERICAL TOOL LIST.

<i>Tool Number</i>	<i>Name</i>	<i>Application</i>	<i>Figure Number</i>	<i>Group Number</i>
2825	Gage	Turbine wheel clearance feeler.....	2-39	14
2827	Expander	Tachometer drive shaft oil seal.....	2-8	1
2835	Bracket	Rear engine lift.....	2-3	4
2864	Fixture	Turbine rear bearing oil seal locating for Hyatt bearings.....	5-42	17
2873	Puller	Coupling and bearing.....	5-6	12
2873-3	Arm	Coupling and bearing puller.....	5-6	12
2873-5	Plug	Coupling and bearing puller.....	5-6	12
2873-6	Plug	Coupling and bearing puller.....	5-6	12
2902	Bracket	Turbine rotor clearance and indicator mounting.....	5-49	8
2947	Expander	Generator drive shaft oil seal.....	2-8	1
2948	Expander	Fuel pump, hydraulic pump, and fuel control governor drive shaft oil seal.....	2-8	1
2952	Eye	Turbine rotor lifting	5-34	15, 16

<i>Tool Number</i>	<i>Name</i>	<i>Application</i>	<i>Figure Number</i>	<i>Group Number</i>
2955	Wrench	Turbine rear bearing retainer nut.....	5-11	16
2956	Holder	Turbine rear shaft.....	5-11	16
2962	Wrench and holder	Turbine front bearing locknut.....	5-5	12
2963	Guide sleeve	Turbine rotor shaft.....	5-9	16
2969	Puller	Turbine front bearing sliding ring.....	5-7	13
2971	Puller	Turbine rear bearing cage impact.....	5-21	17
2973	Yoke	Turbine rotor lifting.....	5-14	16
2980	Drift	Accessories oil seals.....	2-9	1
2988	Gage	Inner exhaust cone depth.....	5-25	6
2994	Stand	Turbine rotor clearance setting and assembly.....	5-34	8, 15, 17
2995	Stand	Engine overhaul.....	2-34	3
2996	Lift	Turbine unit rear.....	5-3	17
3143	Puller	Turbine blade impact.....	2-34	11
3144	Gage	Inner liner centering.....	2-24	9
3145	Fixture	Turbine rear bearing oil seal locating for SKF bearings.....	5-42	17
3147	Pliers	Turbine shaft.....	5-48	12
3273	Reamer	0.135 diameter straight shank fluted chucking.....	2-37	10
3274	Reamer	0.145 diameter straight shank fluted chucking.....	2-37	10
3275	Reamer	0.155 diameter straight shank fluted chucking.....	2-37	10
3613	Extension	Flexible $\frac{3}{8}$ drive x $\frac{7}{16}$ socket.....	2-15	2
3614	Wrench	Turbine sliding ring adjusting.....	5-51	8
3615	Tool	Turbine front bearing retainer ring compressing.....	5-8	13, 15, 16
3629	Stand	Engine transportation and storage.....	2-5	3
3631	Sling	Turbine unit front lift.....	5-4, 5-10	17
3634	Wrench	Turbine front bearing adjusting nut.....	5-35	13, 15
3637	Stand	Turbine unit.....	5-4	17
3653	Puller	Turbine rear bearing and oil deflector.....	5-12, 5-14	16
3654	Gage	0.124 and 0.127 plug.....	2-36	10
3655	Gage	0.134 and 0.137 plug.....	2-36	10
3656	Gage	0.144 and 0.147 plug.....	2-36	10
3657	Gage	0.154 and 0.157 plug.....	2-36	10
3659	Tail pipe and nozzle	Engine test.....	5-56	5
3669	Puller arms	Turbine cooling vanes.....	5-13	16
3670	Gage	0.164 and 0.167 plug.....	2-36	10
3671	Gage	0.174 and 0.177 plug.....	2-36	10
3672	Reamer	0.165 diameter straight shank fluted chucking.....	2-37	10
3673	Reamer	0.175 diameter straight shank fluted chucking.....	2-37	10
3682	Radial Gage	Turbine blade stretch.....	2-33	14
3696	Gage	Fuel pump spline wear.....	2-43	1
6009	Drift	Turbine wheel blade pin.....	2-35	11
6010	Gage	Turbine blade axial location.....	2-38	10
6504	Gage	Accessories upper idler gear key looseness.....	2-11	1
6505	Fixture	Generator drive shaft locking.....	2-11	1
1	Test set	Thermocouple.....	2-53	7
7082	Probe	Thermocouple heater.....	2-54	7
6795808	Brush	Turbine wheel serration.....	2-31	11
9074002	Stand	Turbine assembly.....	5-18	17
9074002-1	Mounting ring	Turbine assembly stand.....	5-18	17
9074005	Yoke	Turbine unit lift.....	5-17	17
9074016	Sling	Aircraft turbine lifting.....	2-3	4
9074017	Eye	Aircraft turbine lifting.....	2-3	4
9074026	Puller	Air adapter fuel filter.....	2-17	2

¹ This test set is Jetcal model BH112J, manufactured by the B & H Instrument Company, Fort Worth, Texas.

SECTION II

MAINTENANCE

2-1. GENERAL INSTRUCTIONS.

2-2. All maintenance instructions apply to both models unless exceptions are specified.

2-3. The maintenance in this section describes operations possible with facilities available at operating activities; minor repair is described in Section V. Trouble shooting and general maintenance is presented first, then maintenance of engine components and systems in logical sequence. Where applicable, maintenance is divided into description, removal, repair, installation, adjustment, testing, torque limits, and extreme weather maintenance.

2-4. Maintenance is restricted to the replacement of faulty components unless instructions are provided.

2-5. The work in this section can be done with authorized hand tools; special service tools are listed in Section I, and they are referred to by group number.

2-6. Although several accessories may be replaced without removing the engine from the aircraft, it often is necessary to remove it so that all external parts will be accessible.

2-7. When an engine has been operated with leaded fuel—gasoline containing tetra-ethyl lead—a yellow residue may be found on parts exposed to exhaust gases. These deposits may cause lead poisoning if inhaled or swallowed. There is little danger in handling contaminated parts if eyes and open cuts are protected; however, be careful to clean parts showing yellow deposits before re-working them.

2-8. Observe all parts closely before cleaning for scoring, burning, or other defects.

2-9. Note the location of each fitting before transferring it to a replacement in order to reconnect the lines correctly. When a hose is installed, the line along its length should be straight; any rotation indicates that it is twisted.

2-10. Do not re-use lockwire, cotter pins, ring seals, lip seals, composition gaskets, and split or tab washers.

2-11. ENGINE DESCRIPTION.

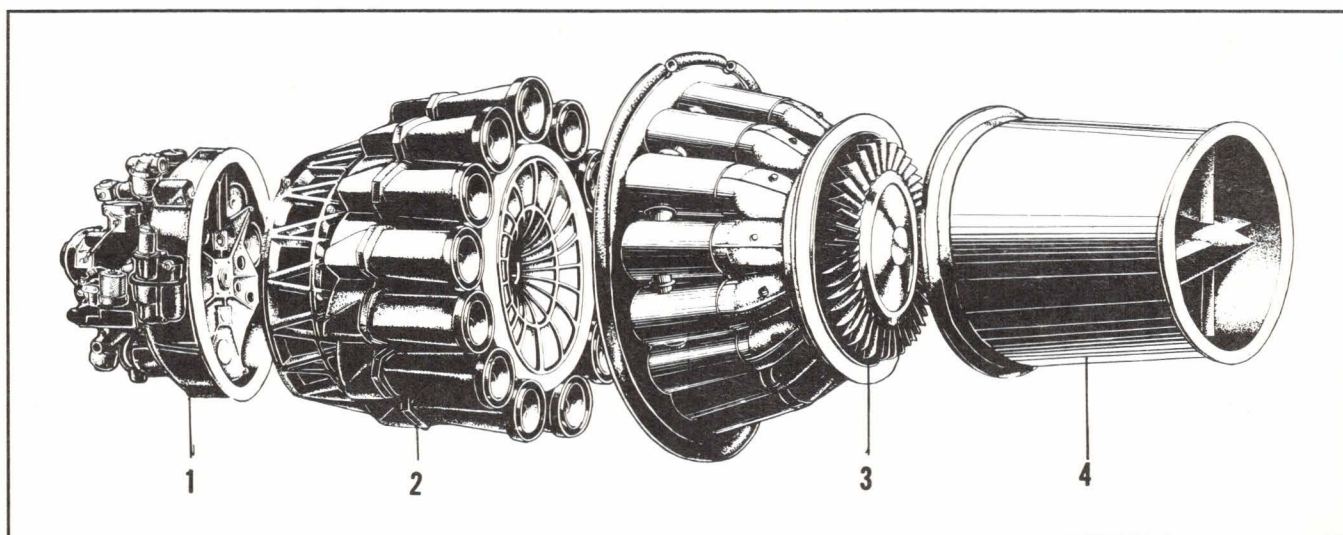
2-12. The engine consists of a dual-entry centrifugal compressor, fourteen through-flow combustion chambers, and a single-stage turbine. (See figure 2-1.)

2-13. The compressor is a double-sided rotor enclosed by casing halves. The rotor impeller has inducer vanes fastened to each face; the impeller shaft, which drives the accessories, is supported by bearings. Truss rings are bolted to the front and rear sides of the casings; guide vanes fastened under these rings direct air into the compressor. The diffuser, fastened between the casing halves, guides compressed air through adapters into the combustion section.

2-14. The ring and tube assembly contains inner liners in which combustion occurs. The combustion chambers are connected by crossover tubes.

2-15. The turbine nozzle, fastened to the ring and tube, directs combustion gases against the turbine wheel to effect compressor rotation.

2-16. The exhaust section consists of inner and outer cones. The outer cone is covered by an insulation blanket.



1. Accessories Case
2. Compressor

3. Turbine Section
4. Exhaust

Figure 2-1. Major Engine Components

32008

2-17. ENGINE OPERATION.

2-18. Air from an external source is directed against the compressor blades by a nozzle to start J33-A-20 engines; J33-A-10A engines are started electrically. Air enters the compressor through the truss rings and guide vanes. Compressed air passes through diffuser passages and the air adapters into the combustion chambers. It enters a series of holes into the inner liners, where fuel is sprayed into it and the mixture is burned. Hot gases exit from the aft end of the combustion chambers; a turbine nozzle directs the gases against the turbine wheel blades to effect turbine rotation. The turbine wheel drives the compressor by means of a splined coupling. From the turbine wheel, the gases travel through the exhaust cone and out an aircraft-furnished tailpipe and jet nozzle. (See figure 2-2.)

2-19. SPECIFICATIONS.

Normal rating

Speed 96% (11,250 rpm)
Static thrust 3900 lb
Duration Continuous

Military rating

Speed 100% (11,750 rpm)
Static thrust 4600 lb
Duration 30 minutes

Take-off

Speed 100% (11,750 rpm)
Static thrust 4600 lb
Duration 5 minutes

Above ratings are based upon

Fuel specification

J33-A-10A MIL-F-5572 (grade 100/130)
J33-A-20 MIL-F-5624A (grade JP-4)
Alternate MIL-F-5572 (grade 100/130)
Oil specification MIL-O-6081 (grade 1010)
Standard sea level conditions Static

Maximum actual measured exhaust gas temperature

(J33-A-10A)

Take-off and military 700°C (1290°F)
Normal and below 655°C (1210°F)
Starting and acceleration (See table I)

Maximum actual measured exhaust gas temperature

(J33-A-20)

Take-off and military 716°C (1320°F)
Normal and below 655°C (1210°F)
Starting and acceleration (See table I)

Ground idle speed 34% (400 rpm)

Weight less starter, generator, and tachometer generator

J33-A-10A 1771 lb
J33-A-20 1800 lb

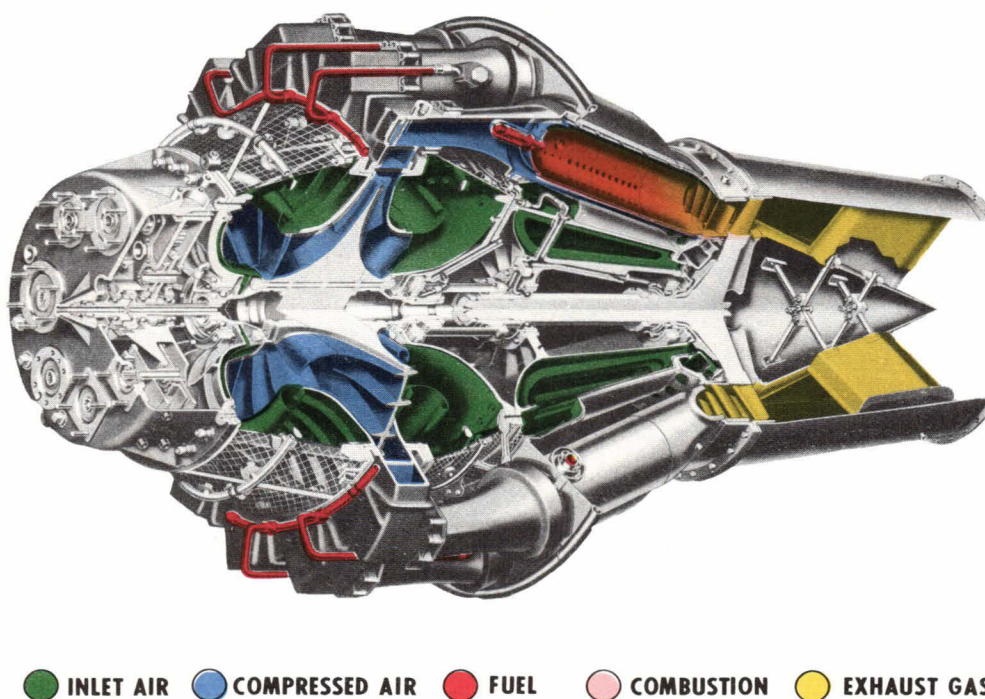
Maximum over-all dimensions

At room temperatures

Length 104³³/₆₄ inches
Diameter 48³³/₃₂ inches
Width across trunnion supports 51⁷/₈ inches

At maximum operating temperatures

Length 105 inches
Diameter 48¹³/₃₂ inches
Width across trunnion supports 52³/₁₆ inches



● INLET AIR ● COMPRESSED AIR ● FUEL ● COMBUSTION ● EXHAUST GAS

Figure 2-2. Air Flow and Combustion

65001

2-20. TROUBLE SHOOTING.**Note**

Starred items are likely to occur only on initial installation.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
The engine fails to start.	Lack of fuel to the engine.	Check fuel pump inlet pressure by attaching a calibrated gauge to the fuel inlet pressure-sensing connection.
	Insufficient fuel in tanks.	
	*Aircraft fuel system defective.	Check the aircraft fuel system.
	*Aircraft linkage incorrectly adjusted.	Check the aircraft linkage, making certain that the cutoff valve on the fuel control is opening.
	Cold weather.	(Refer to paragraph 2-172.)
	Defective flowmeter.	Check flowmeter for obstruction to flow.
	Water or other contaminant in fuel.	Check a sample of fuel from the bottom of the tank. If contaminated, drain all fuel from the aircraft and flush the system. Refill with the correct fuel.
	*Air in starting fuel control lines.	Try a second start.
	*Flushing oil temporarily fouling igniter plugs.	Try a second start.
	Starting fuel control inlet solenoid valve inoperative.	Check the electrical connection at the starting fuel control. (See figure 4-1.) Check the throttle switch on the main control for an open circuit. Check for a defective cockpit starting fuel control switch. If the starting fuel control inlet valve solenoid is defective, replace the control. (Refer to paragraph 2-186.)
	Drip valve sticking open.	Replace the starting fuel control. (Refer to paragraph 2-186.)
	Regulator valve in the starting fuel control stuck.	Replace the control.
	No spark obtained at either igniter plug.	Check all ignition disconnects. If they are satisfactory, check for defects between the battery and the aircraft ignition exciter unit. Check the battery. A minimum of 16 volts is required at the dynamotor for normal sparking rate and 18 volts for a high sparking rate. Check the connection from the battery to the dynamotor. The <i>BAT</i> terminal on the aircraft filter box must connect to the plus side of the battery box. Check control switches and the dynamotor.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
The engine fails to start. (Cont)		<p>Check the ignition transformers by substituting satisfactory units.</p> <p>Check the plugs for broken electrodes. (Refer to paragraph 2-265.) Replace damaged plugs.</p> <p>Check the igniter plug gap. (Refer to paragraph 2-265.)</p>
	Main battery switch <i>OFF</i> .	
	Starting circuit switch <i>OFF</i> .	
	Starter fails to crank or starter speed low.	<p>Check the auxiliary power supply and the starter. The voltage to the engine starter must be 24-28 volts, and the current must not exceed 1000 amperes. Each start must not exceed 20 seconds. Turn off power to the starter if the engine does not fire within 10 seconds. Allow one minute between each starting attempt. In order to obtain the high torque required, the voltage measured across the starter terminal and the aircraft frame must be maintained at a high level. To obtain satisfactory 10% (1175 rpm) starts at all temperatures, the voltage across the starter should not be less than 20 volts when the speed levels off at firing. In order to get maximum voltage at the starter, all electrical connections and contacts in the starter load circuit, both aircraft and engine, must be clean, smooth, and tight. The batteries must be kept in good condition. Use two lead cables for every start.</p>
	No power supply to the sarter.	<p>Turn off all fuel and ignition switches and the selector valve. Disconnect leads to the starter. Turn on the starter switch; check the power supply at the starter lead. If there is no power, check continuity of all wiring and check the voltage supply and voltage output at the starter control. Replace the control if defective.</p>
	Open circuit in starter.	(Refer to paragraph 2-243.)
	Starting clutch in the accessories gear casing damaged.	Replace the engine.
Spark obtained at only one igniter plug.	Defective igniter plug, high-tension lead, or ignition transformer.	Replace each unit successively with a satisfactory one.
	Defective aircraft ignition exciter unit.	Replace the exciter unit.
	Defective discharge tubes in the exciter.	Replace the discharge tubes.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
Starting temperatures too high or temperatures of acceleration to change-over speed too high.	Foreign material in the starting fuel control dashpot piston bleed or piston stuck in lowest position.	Replace the starting fuel control.
<p>Note</p> <p>If the elevation of the air field is over 4000 feet, adjust the starting fuel control. (Refer to paragraph 2-190.)</p>	Regulator valve in the starting fuel control stuck open.	Replace the starting fuel control.
	Drip valve stuck closed.	Replace the starting fuel control.
	Excessive leaking of fuel from the main fuel control.	Check linkage to the fuel controls. (Refer to paragraph 2-38.) To check controls for leaks at <i>CLOSED</i> position, disconnect the hose from the main fuel control to the main check valve. Turn off the ignition switch or disconnect the igniter plug leads. With the cockpit throttle closed and the boost pump <i>ON</i> , motor the engine with the starter. Fuel leaking up to 20 cc per minute is allowed from either control. If excessive flow occurs, check linkage and adjust. Replace the control if excessive leaking continues with the throttle closed.
The engine starts slowly and the temperature of acceleration to the change-over speed is too high.	Starting fuel control cutoff valve stuck closed or foreign material in cutoff bleed.	Replace the starting fuel control.
	The starter drops out too soon.	The starter must be adjusted to drop out at 17-19% speed (2000-2230 rpm).
	Engine manifold No. 7 or 14 check valve leaking or bleed plugged in No. 7 and 14 fuel manifold supply port at the starting fuel control.	Increase and decrease engine speed for several cycles. If no improvement results, replace the valve.
	Incorrect fuel for starting.	
Engine acceleration to the change-over speed too slow or acceleration temperature too low.	Inner liner crossover tubes misaligned.	Inspect the inner liners for misalignment. Rotate the spacers until the tube aligns within $\frac{1}{16}$ inch of the crossover tube entrance to the liner and clip assemblies. (See figure 2-25.)
	Foreign material in starting fuel control dashpot piston bleed; dashpot piston sticking.	Replace the starting fuel control.
	Regulator valve in the starting control sticking.	Replace the starting fuel control.
Excessive exhaust gas temperature at change-over speed.	Fuel supply to starting fuel control too low.	(Refer to paragraph 2-203.)
	*Main control throttle switch not breaking circuit at change-over.	Replace the switch if a short circuit is found.
	Foreign material under solenoid-operated inlet valve seat in the starting fuel control.	Increase and decrease engine speed for several cycles. If no improvement results, replace the control.
Engine unable to reach full speed with all engine gauges reading normal.	Ambient temperature too low to reach 100% speed.	100% speed not necessary to obtain full thrust.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
Engine unable to reach full speed on main fuel system.	*Main fuel control maximum speed stop not reached.	Check linkage between cockpit throttle lever and main fuel control.
	*Obstruction in the fuel supply to the engine.	Check lines for obstruction. Clean aircraft fuel filters.
	Fuel leaks.	Check all piping and connections.
	Fuel pump defective.	Replace the pump. (Refer to paragraph 2-173.)
	Fuel control relief valve or bypass valve stuck open.	Increase and decrease engine speed for several cycles. If no improvement results, replace the control.
	Aneroid bellows failure.	Replace the fuel control.
	Tachometer indicator reading inaccurate.	Recalibrate the gauge. Check the tachometer generator by substituting a satisfactory unit.
	*Tachometer generator electrical leads reversed.	
	*Wrong tachometer generator installed.	Check the airframe handbook.
	Drip valve leaking.	If the drip valve leaks excessively during normal operation, replace the starting fuel control.
Fuel pressure fluctuates.	Main fuel control altitude compensating needle stuck, giving flow for higher altitude.	Replace the control.
	*Flushing oil not removed from the main fuel control.	Flush the control of all oil and let it stand filled with fuel for eight hours. If the soaking and several hours of normal engine running do not stop the fluctuating, replace the control.
<p>Note</p> <p>Fuel pressure fluctuation is not detrimental unless accompanied by exhaust gas temperature fluctuation and engine speed fluctuations.</p>		
Acceleration temperature too high during ground operation.	Defective exhaust gas temperature sensing and indicating system.	Check the system and recalibrate the gage if necessary. (Refer to paragraph 2-272 or 2-277.)
	Starting fuel system supplying additional fuel.	Check the solenoid of the starting fuel control inlet valve.
Temperature too high during acceleration.	Main fuel control bypass valve or governor valve sticking.	Increase and decrease engine speed for several cycles. If no improvement results, replace the fuel control.
Excessive exhaust gas temperature.	Exhaust gas temperature gauge reading inaccurate.	Recalibrate the gauge.
	Faulty tachometer generator or indicator.	Replace defective units.
	Fuel nozzles out of balance. Inner combustion chamber damaged.	Inspect the inner area of the exhaust cone for heat streaks or excessive warping. The location of heat streaks on the

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
Excessive exhaust gas temperature. (Cont)		inner surfaces of the exhaust cone indicates roughly the location of the combustion chamber with a faulty nozzle or a faulty inner chamber. Replace defective nozzles, but do not disassemble them.
	Foreign matter clogging compressor inlet ducts.	Remove obstructions.
	Damaged turbine wheel blades or turbine nozzle.	(Refer to paragraph 2-125 and 2-132.)
	*Inside diameter of the airplane tail pipe outlet below the allowable limits.	Check the tail pipe diameter with the aircraft table of limits. Replace under-size tail pipes.
Vibration.	Loose front engine support.	Tighten the mount and check for wear in the ball joint.
Engine speed fluctuates.	Low fuel supply.	Check the pump inlet pressure by attaching a calibrated gauge to a tee in the fuel inlet fitting.
	Foreign material lodged within the fuel control, causing the pressure regulator, governor valve, or bypass valve to stick.	Increase and decrease engine speed for several cycles. If no improvement results, replace the fuel control.
	Starting fuel system supplying additional fuel.	Check the starting fuel control inlet valve for leakage.
	Water or other contaminant in fuel.	Check a sample of fuel drained from the bottom of the tank. If contaminated, drain fuel from all tanks, and flush the system. Refill with the specified fuel.
	Governor valve spring not square.	Replace the control with part number 6811006 fuel control for the J33-A-20.
	Faulty aircraft boost pumps.	Make aircraft fuel system check.
Engine overspeeds.	Faulty tachometer generator or indicator.	Check the tachometer generator by substituting a satisfactory unit. (Refer to paragraph 2-260.) Recalibrate the indicator.
	Starting fuel control supplying extra fuel.	Check the starting fuel control inlet valve for leaking.
	Fuel control maximum governor speed set too high or governing mechanism defective.	Refer to paragraph 2-62 regarding checking and setting the fuel control maximum throttle stop. If the engine overspeeds after having operated satisfactorily for several hours do not reset the main control maximum throttle stop until the cause of overspeeding is discovered. Check the full-throttle lock bolt and the maximum speed adjustment for tightness.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
Engine speed in the power range increases with altitude at fixed throttle.	Main fuel control altitude needle sticking.	Replace the main fuel control.
	Main fuel control by-pass valve sticking.	Increase and decrease engine speed for several cycles. If no improvement results, replace the fuel control.
	Fuel control aneroid bellows failed.	Replace the fuel control.
Idle speed too high at altitudes over 30,000 feet.	Excessive leaking past the main fuel control regulator valve; regulator valve sticking.	Cycle control as shown above. Replace the main fuel control if no improvement results.
	Main fuel control altitude needle sticking in rich position.	Replace the control.
	Starting fuel system supplying additional fuel.	Check the starting fuel control inlet valve and solenoid. Replace the control if valve is malfunctioning.
Idle speed too low at altitude.	Main fuel control bypass or relief valve stuck open.	Increase and decrease speed several cycles. Replace the fuel control if no improvement results.
	Idle bleed in main control plugged.	Replace the control.
Rumbling noise with movement of throttle.	Loose engine mounts.	Inspect the spindle trunnion supports, the front engine mount ball-socket joint, the air intake ducts, and the aircraft tail pipe mounts for looseness.
Excessive fuel leaking from drains.	Starting fuel control drip valve stuck.	Replace the starting fuel control if necessary. (Refer to paragraph 2-188.)
	Defective accessory or seal.	Isolate the accessory which leaks and replace the seal or replace the unit.
	*Cutoff valve not closing.	Check the aircraft linkage.
Low oil pressure. (See table VII.)	Gauge records inaccurately.	Recalibrate the gauge.
	Lack of oil in the reservoir.	
	Clogged oil filters.	
	Defective oil pump.	Remove the pump and check for a sheared drive.
	Oil leaks.	Check all piping and connections.
High oil pressure. (See table VII.)	Oil pressure gauge records inaccurately.	Recalibrate the gauge.
	Incorrect oil.	
	Plugged pressure oil line.	If an external oil line is plugged, remove and clean it. If an internal oil passage is plugged, remove the engine.
Excessive oil consumption.	Loose fittings or connections.	Tighten loose connections.
	Excessive clearance around oil seals.	(Refer to paragraph 2-72.)
	Excessive high speed ground operation.	Check oil consumption during flight.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
Burning continues after closing throttle.	*Main control shutoff valve not seating.	If combustion does not stop, operate the starter with all fuel switches off. Check the linkage to the main fuel control. (Refer to paragraph 2-38.) If necessary, replace the main fuel control.
	Combustion chamber drain lines clogged.	Remove and clean.
	Faulty drip valve.	(Refer to paragraph 2-191.)
	Excessive carbon on the combustion domes and liners.	(Refer to paragraphs 2-107 and 2-122.)
Engine flameout.	Malfunction of aircraft accessories.	Check aircraft fuel system.
	Faulty fuel nozzles.	(Refer to paragraph 2-208.)
	Clogged fuel filters.	Check for ice immediately upon landing.

2-21. ENGINE REMOVAL.

(Tool Groups No. 3 and 4.)

2-22. Whenever an engine is removed from an airframe and placed in storage, prepare it for storage in accordance with applicable instructions. (Refer to Section IV.)

- Disconnect aircraft connections.
- Install the engine lifting bracket in the two rear lifting bosses on the ring and tube assembly. Install the lifting eye into the boss on the No. 1 diffuser elbow. Attach the lifting sling. (See figure 2-3.)
- Attach the lifting hoist and remove any slack.
- Remove the aircraft parts which secure the engine trunnion spindles and front support to the aircraft structure.

CAUTION

Be sure that the spindle bolt set screws are loosened before removing the spindle bolts.

- Carefully remove engine from aircraft and place in an engine stand. (See figures 2-4 and 2-5.) Prevent the engine from swinging during transfer.
- If the engine is to be prepared for storage, remove the combustion chamber drain valve from the aircraft and attach the valve to the engine.

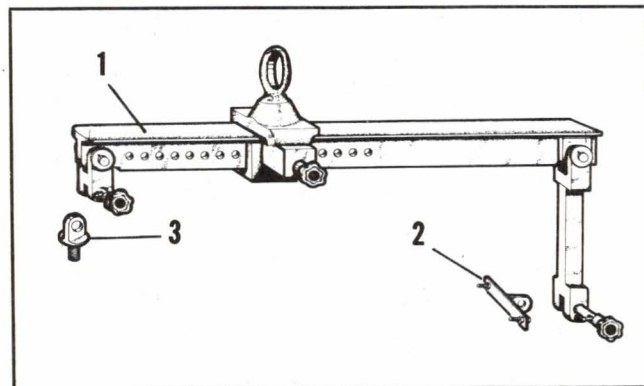
2-23. MAINTENANCE.

2-24. LOCKWIRE SPECIFICATIONS. Use 0.032 diameter lockwire, AN995C32, in all locations accessible for normal field servicing; use 0.020 diameter, AN995C20, for No. 8 screws or smaller, electrical har-

ness coupling nuts, and places where larger wire will not fit. Safety all drilled bolts, plugs, and screws, except those locked with self-locking nuts or lockwashers. Lockwire bolts in pairs where possible. Lace insulation pads and inlet screens with a double figure-eight pattern. (See figure 2-6.) When it is not practical to use a figure eight lacing, lockwire hooks in a circular pattern. Secure inlet screen lacing wire ends with soft solder in accordance with specification AMS 4750 (QQ-S-571, grade A). When reassembling, be sure to safety wherever lockwire was removed. Do not use zinc lockwire.

2-25. KLINCHER LOCKNUTS. Apply Kano-Kroil before attempting removal. For installation, follow this procedure:

- Inspect bolts for thread damage before installing.



- 1, Sling No. 9074016
- 2, Bracket No. 2835
- 3, Eye No. 9074017

Figure 2-3. Engine Lifting Tools

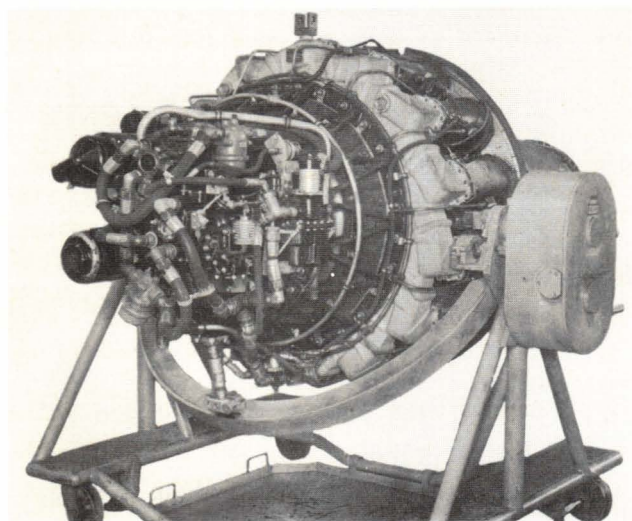


Figure 2-4. Engine Overhaul Stand No. 2995

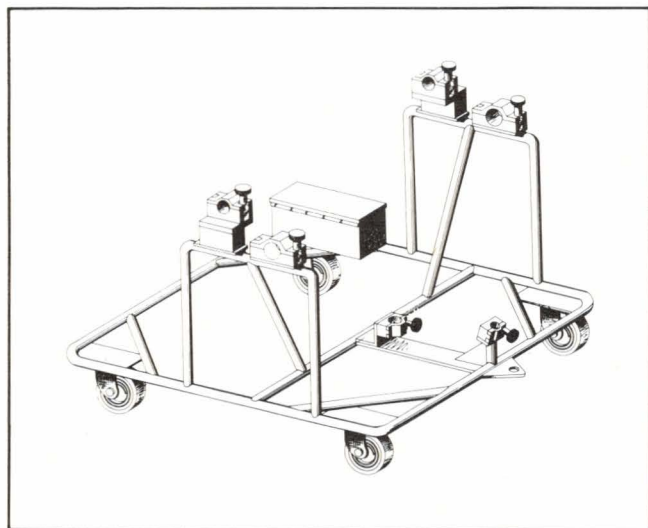


Figure 2-5. Engine Transportation and Storage Stand No. 3629

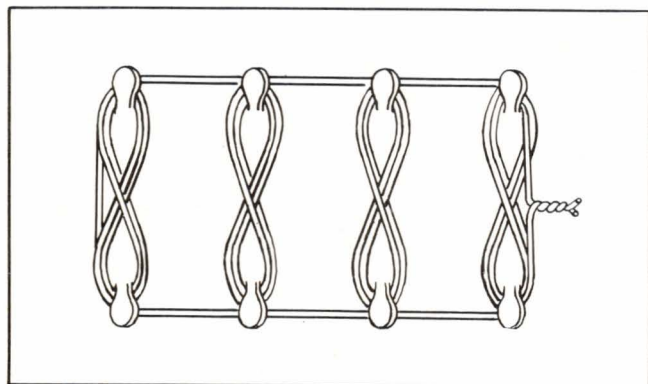


Figure 2-6. Lockwire Lacing Pattern

b. Apply the thread lubricant in paragraph 2-30.

c. Use pilot drifts to align the bolt holes. Thread damage will cause seizure.

d. Install the nut with the hexagonal end away from the flange. Use enough stainless steel washers that the bolt extends only one and one-half threads beyond the nut.

2-26. CORROSION PREVENTION.

a. On steel surfaces, clean the area to be touched up with trichloroethylene. Let dry for 5-10 minutes. Apply No. 505 Aluminum Polytherm, manufactured by Interchemical Corporation, New York, New York, or Sicon 3X222, manufactured by Midland Industrial Finishes Company, Waukegan, Illinois. Let dry at least one hour at room temperature.

b. Touch up magnesium-alloy parts with chrome-pickle in accordance with Specification MIL-M-3171, type I. Repaint if the surface was originally painted.

c. On aluminum alloy parts which were originally painted without anodizing, touch up the reworked areas with zinc chromate primer, Specification MIL-P-6889, and repaint.

d. On aluminum-alloy parts which were originally anodized, clean the damaged area with an approved organic solvent and rinse the part with water. Treat the damaged area in accordance with Specification MIL-C-5541; chromic acid is an alternate. If the coating is powdery, dilute the solution; if no visible coating forms, increase the solution concentration or the reaction time.

2-27. CLEANING.

a. The cleaning solvent recommended for non-ferrous parts is Specification No. P-S-661 or equivalent. Clean steel parts with a water solution. All parts may be cleaned with a cold dip.

b. Clean combustion and exhaust components by scrubbing them with a stiff brush dipped in cleaning solution USAF Specification No. 14119. Allow the solution to remain on the parts 10-15 minutes. Wash the parts with water after cleaning; no neutralizer is required.

2-28. WELDING.

a. For inert-gas welding use MIL-R-5031, composition 6, weld rod.

b. For metallic arc welding use MIL-E-6844, class 6, weld rod.

2-29. DYE-CHECK INSPECTION. Use R40-K-100 dye-check kit, made by Turco Products, Inc., Los Angeles, California, to inspect for cracks.

a. Clean the area to be inspected.

b. Brush the penetrant on the area and allow it to stand 10 minutes.

c. Wipe the penetrant off with a clean cloth.

d. Spray or brush the area with developer and blow off any excess. Allow it to dry.

e. A bright-colored contrasting or dotted line will indicate a crack.

2-30. LUBRICATION. Apply only a light coat of lubricant by hand, and wipe off any excess. Lubricate only the male threads of fuel and oil lines; wipe the lubricant from the lead threads to prevent its entering the systems.

2-31. Ab-lube is a high-temperature lubricant and anti-seize compound. It is a mixture of one part Navy stock number R14L550 and one part R51DCR-550R.

2-32. Ferro-Cote is made by Quaker Chemical Products Company, Conshohocken, Pennsylvania. Kano-Kroil penetrating oil, part number 6743087, is made by Kano Laboratories, Nashville, Tennessee; it is Navy Specification D-2-B.

2-33. Use these lubricants on removal and installation of engine components:

Time	Location	Lubricant
Removal Installation	Exhaust cone-to-ring and tube bolts	Kano-Kroil
	Ring seals	MIL-L-6082 (grade 1065)
	Sleeves on solid piping, surfaces that contact coupling nuts	MIL-L-6082 (grade 1100)
	Male threads of straight threaded connections	MIL-O-6081 (grade 1010)
	ID of rubber tubing that connects to metal tubing	MIL-O-6081 (grade 1010)
	Front support ball cap and seat concave surfaces	AN-P-51
	Front support female threads	MIL-L-3572
	Generator male and female splines*	Ab-lube
	Main fuel control male and female splines*	Ab-lube
	Hydraulic pump male and female splines*	Ab-lube
	Fuel pump male and female splines*	Ab-lube
	Tachometer-generator socket drive	Ab-lube
	Male threads and shoulder of fuel nozzle	MIL-L-3572
	Air adapter filter plug	MIL-L-3572
	Air adapter mounting bolts or diffuser bushings	JAN-A-669
	Combustion chamber liner positioning bolts	Ab-lube
	Trunnion spindle ID, OD, male threads, and female threads	Ab-lube
	All bolt threads except those with Boots locknuts at ring and tube-to-exhaust cone split line	Ab-lube
	All Boots locknuts after cleaning	Ferro-Cote No. 348-S-1
	Thermocouple mounting nuts	Ab-lube

*Soak a felt plug in Ab-lube and install it in the female splines.

2-34. SEALING COMPOUNDS. For specific applications, refer to installation of the components.

a. When reassembling a part containing an asbestos compound gasket, reuse the original gasket if no sealing compound was applied.

b. Use no sealing compounds on any gaskets or split lines unless specified.

c. When installing made threads of tapered threaded connections and cooling and vent line flanges, bolt threads, and gaskets use Permatex No. 3, made by Permatex Company, Brooklyn, New York.

2-35. UNIVERSAL FITTINGS.

2-36. Use this procedure to install universal fittings with back-up rings:

a. Install the nut on the fitting and run it back until the counterbore of the nut aligns with the upper inner corner of the gasket groove.

b. Work the back-up ring into the counterbore of the nut.

c. Lubricate the seal and install it on the fitting.

d. Turn the nut down until the seal is pushed firmly against the lower threaded section of the fitting.

e. Install the fitting into the boss, making certain the nut turns with the fitting, until the seal touches the boss. Then tighten it one and one-half turns more.

f. Put a wrench on the nut to prevent its turning, and position the fitting by turning it not more than one turn.

g. Hold the fitting in its position and tighten the nut against the boss.

2-37. Use this procedure to install universal fittings without back-up rings:

a. Run the nut on the fitting end back until the washer face is aligned with the upper inner corner of the gasket groove.

b. Lubricate the seal and place it in the groove.

c. Screw the fitting into the boss until the seal barely touches the boss.

d. Turn the fitting and nut together until the nut touches the boss.

e. Put a wrench on the nut to prevent it turning, and position the fitting by turning it in up to 270° or unscrewing it up to 90°.

f. Hold the fitting in its proper position and tighten the nut against the boss.

2-38. PRE-OPERATIONAL ADJUSTMENTS.

2-39. Whenever an engine is installed initially in an aircraft or whenever the main fuel control is replaced, check and adjust the controls and linkage.

2-40. On J33-A-10 engines, make sure that the clevis pin which connects the interlink to the main fuel control cutoff lever is installed with the head outboard.

2-41. Attach the aircraft throttle rod to the main control, observing the following precautions:

a. Aircraft throttle should have approximately 1/8 inch spring-back at the throttle quadrant in the closed position when main control is at cutoff.

b. Aircraft throttle should have approximately 1/8 inch spring-back at the throttle quadrant in the open position when the main control is against the maximum speed stop.

2-42. Operate the control from closed to open position several times to be certain that no control linkage jamming is possible.

2-43. ENGINE INSTALLATION. (Tool Group No. 4.)

2-44. Install the engine lifting bracket in the two rear lifting bosses on the ring and tube. Install the lifting eye into the boss on the No. 1 diffuser elbow. Attach the lifting sling. (See figure 2-3.) Place the engine in the airframe in accordance with instructions in the applicable airframe handbook. Prevent the engine from swinging during transfer.

2-45. EXHAUST GAS TEMPERATURE MEASUREMENT.

2-46. Check the exhaust gas temperature and rpm with Jetcal analyzer model BH112J or equivalent at regular intervals and whenever the operating temperature seems abnormal. Follow the instructions provided with the analyzer. The limits below will be useful only if the temperature-measuring system has been checked carefully.

2-47. EXHAUST GAS TEMPERATURE LIMITS.

2-48. The maximum temperature allowed for continuous operation is 716°C (1320°F). Temperatures between 716°C (1320°F) and 899°C (1650°F) are permissible for only 20 seconds. The exhaust gas temperature never should exceed 899°C (1650°F). See table I when overtemperature occurs.

2-49. Table II is a guide to exhaust gas temperatures at various compressor inlet temperatures. During operation with compressor inlet temperatures above 53°C (128°F) it will usually be necessary to reduce engine speed below 100% (11,750 rpm) to prevent the exhaust gas temperature from exceeding 716°C (1320°F).

2-50. At compressor inlet temperatures below -28°C (-19°F), 100% speed (11,750 rpm) may not be obtainable because of fuel flow limitation. When this situation exists, check the exhaust gas temperature at 96% speed (11,280 rpm). For speeds normally obtainable at full throttle at low inlet temperature operation, see table III.

TABLE I

Starting and Acceleration Overtemperature Limits

Exhaust Gas Temperature °C (°F)	Time Seconds	Action Required
900-999 (1625-1830)	0-5	Make entry in log book*
	Over 5	Make a visual inspection of turbine blades and exhaust cone for damage.
Reaches 1000 (1832)	0-2	Make entry in log book*
	Over 2	Make an overtemperature inspection. (Refer to paragraph 3-4.)

*Record each overtemperature, its duration, and its possible cause in the USN Engine Log Book. Take remedial action if two successive overtemperatures occur. After a combined total of ten entries, make an overtemperature inspection.

TABLE II

Exhaust Gas Temperature vs Compressor Inlet Temperature		
Compressor Inlet Temperature °C (°F)	Exhaust Gas Temperature 100% Speed °C (°F)	96% Speed °C (°F)
53 (128)	716 (1320)	
49 (120)	710 (1310)	
43 (110)	704 (1300)	
38 (100)	699 (1290)	
32 (90)	694 (1281)	
27 (80)	692 (1278)	
21 (70)	689 (1272)	
16 (60)	686 (1267)	
10 (50)	684 (1263)	
4 (40)	683 (1261)	
-1 (30)	682 (1260)	
-7 (20)	682 (1260)	610 (1130)
-12 (10)	682 (1260)	608 (1127)
-18 (0)	681 (1258)	607 (1125)
-23 (-10)	682 (1260)	606 (1124)
-29 (-20)		607 (1125)
-34 (-30)		608 (1127)
-40 (-40)		609 (1129)
-46 (-50)		611 (1131)
-51 (-60)		612 (1133)
-54 (-65)		612 (1134)

CAUTION

The engine speeds listed in table III at low inlet temperatures are those normally obtainable. Do not make throttle-stop adjustments at these low inlet temperatures.

2-51. Maintain at least 260°C (500°F) exhaust gas temperature except during the final approach for landing.

2-52. OVERTEMPERATURE OPERATION.

2-53. See table I for overtemperature limits. Each time the exhaust gas temperature exceeds 900°C (1652°F) make an entry in the engine log book or in DD Form 781; inspect the engine in accordance with applicable instructions when 10 entries are recorded after the last inspection. If the exhaust gas temperature is 900-999°C (1652-1830°F) for more than 5 seconds, inspect the engine; and if the exhaust gas temperature exceeds 999°C for more than 2 seconds, inspect the engine.

TABLE III

Minimum Engine Speed Normally Attainable During Low-temperature Operation	
Compressor Inlet Temperature °C (°F)	Engine Speed % (rpm)
-29 (-20)	99.9 (11,740)
-34 (-30)	99.1 (11,650)
-40 (-40)	98.4 (11,565)
-46 (-50)	97.6 (11,470)
-51 (-60)	96.8 (11,380)

TABLE IV

Engine Speed Limits	
Remove engine if momentary overspeed exceeds.....	105%
Make a 60-hour inspection if overspeed reaches.....	103-105%
Make a 60-hour inspection if overspeed for more than 15 seconds reaches.....	101-103%
Make a preflight inspection if momentary overspeed less than 15 seconds reaches.....	101-103%
Reset control for overspeed between.....	101-105%
Normal ground setting.....	100-101%
Ground idle setting.....	34-35%

2-54. ENGINE SPEED LIMITS.

2-55. Engine speed limits are shown in table IV. Always use the analyzer in tool group No. 7 or equivalent to check engine speed. Follow the instructions provided with the analyzer.

2-56. ENGINE SPEED AND THRUST.

2-57. At compressor inlet temperatures above 15°C (59°F), 100% thrust may not be obtainable even though 100% speed (11,750 rpm) is possible. At least 100% thrust will be obtained at engine speeds varying from 100% (11,750 rpm) at 15°C (59°F) down to 87% (10,200 rpm) at -55°C (-67°F).

2-58. OPERATIONAL ADJUSTMENTS.

2-59. Do not operate an installed engine at 96% speed (11,280 rpm) or above for more than one minute while the aircraft is on the ground and the access doors are closed.

2-60. The engine oil pressure must be within the limits shown in table VII.

CAUTION

On J33-A-20 engines, do not make manual starts.

2-61. Adjust the main fuel control.

2-62. MAIN FUEL CONTROL THROTTLE STOP SETTING.

a. Start the engine and slowly increase speed to full throttle, being careful not to exceed 101% (11,870 rpm). (See table IV.) Do not attempt to set the throttle stop when the ambient temperature is below -14°C (6°F).

Note

The exhaust temperature must not exceed 715°C (1319°F).

b. If the engine fails to reach rated speed or tends to exceed the normal ground setting of 100-101% (11,750-11,870 rpm) with slight additional throttle increase, change the setting of the maximum speed adjustment screw. Turning the screw clockwise reduces speed, turning it counterclockwise increases speed.

c. Reduce engine speed to idle and make a tentative adjustment.

d. Advance the throttle and check the full-throttle speed; repeat this process until the maximum speed is within limits.

2-63. MAIN FUEL CONTROL IDLE ADJUSTMENT.

a. There is no provision for field adjustment of the idle setting in the main control. Make the idle setting by adjustment on the cockpit throttle quadrant.

b. With the engine operating at 34% (4000 rpm) on the main fuel system, set the idle detent in the cockpit. Accelerate the engine to approximately 68% (8000 rpm) and then retard the throttle to idle detent. The idle speed should stabilize at 34-35% (4000-4125 rpm).

2-64. TORQUE LIMITS.

2-65. The following paragraphs contain general torque limits for nuts, bolts, and screws; special applications are provided under the specific component.

2-66. Do not use a thread lubricant unless one is specified. Threads must be free of burrs or nicks, and they must turn freely. Final tension applied at the first draw-down causes uneven tension and warped split lines. First tighten the unit in staggered sequence until the parts are seated firmly at the split line; then tighten in a series of gradually-increased torque applications until the required tension is obtained.

2-67. BOLTS, NUTS, AND SCREWS.

Size	Type	Torque
8-32	Screws, bolts, and nuts.....	10-15 lb in.
10-24	Screws.....	15-20 lb in.
10-24	Bolts and nuts.....	20-30 lb in.
10-32	Screws.....	20-25 lb in.
10-32	Bolts and nuts.....	30-40 lb in.
1/4-20	Bolts and nuts.....	70-85 lb in.
1/4-28	Flat and fillister head screws.....	35-50 lb in.
1/4-28	Socket head screws.....	80-100 lb in.
1/4-28	Bolts and nuts.....	80-100 lb in.
5/16-24	Bolts and nuts.....	140-180 lb in.
5/16-24	Self-locking nuts.....	160-190 lb in.
3/8-16	Bolts and nuts.....	225-265 lb in.
3/8-24	Bolts and nuts.....	240-300 lb in.
3/8-24	Self-locking nuts.....	265-325 lb in.
7/16-14	Bolts and nuts.....	360-480 lb in.
7/16-20	Bolts and nuts.....	420-540 lb in.
1/2-20	Bolts.....	60-75 lb ft
9/16-12	Bolts.....	70-85 lb ft
9/16-18	Bolts.....	75-90 lb ft
5/8-18	Bolts.....	80-100 lb ft
	Palnuts.....	Tighten finger-tight; then one extra flat

2-68. FUEL, OIL, AIR, AND DRAIN LINES. When tightening or loosening hose coupling nuts, make sure that the hose nipple does not turn on the seat of the mating fitting.

Section II
Paragraph 2-69 to 2-73

AN 02B-105BB-2

Thread Size **Torque**
FLEXIBLE HOSE WITH ALUMINUM COUPLING NUTS ON ALUMINUM FITTINGS

7/16-20	40-65 lb in.
9/16-18	80-120 lb in.
3/4-16	150-200 lb in.
7/8-14	200-350 lb in.
1 1/16-12	300-500 lb in.
1 5/16-12	40-60 lb ft
1 7/8-12	80-100 lb ft

FLEXIBLE HOSE WITH STEEL COUPLING NUTS ON STEEL FITTINGS

7/16-20	125-175 lb in.
9/16-18	200-250 lb in.
3/4-16	325-420 lb in.

SOLID STEEL TUBE WITH STEEL OR ALUMINUM COUPLING NUTS ON ALUMINUM FITTINGS

7/16-20	65-100 lb in.
9/16-18	125-175 lb in.
3/4-16	250-325 lb in.

SOLID STEEL TUBE WITH STEEL OR ALUMINUM COUPLING NUTS ON STEEL FITTINGS

7/16-20	80-120 lb in.
9/16-18	200-250 lb in.
3/4-16	325-400 lb in.

ALUMINUM TUBING AND ALUMINUM COUPLING NUTS ON ALUMINUM FITTINGS

7/8-14	200-350 lb in.
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FLEXIBLE HOSE WITH ALUMINUM COUPLING NUTS ON STEEL FITTINGS OR STEEL COUPLING NUTS ON ALUMINUM FITTINGS

7/16-20	65-100 lb in.
9/16-18	125-175 lb in.
3/4-16	250-325 lb in.
1 5/16-12	40-60 lb ft

UNIVERSAL FITTING LOCKNUTS

7/16-20	55-80 lb in.
9/16-18	100-150 lb in.
3/4-16	200-300 lb in.
3/4-16 Starting fuel control inlet.	150-200 lb in.
7/8-14	300-450 lb in.
1 1/16-12	420-600 lb in.
1 5/16-12	50-70 lb ft
1 7/8-12	65-85 lb ft
1 7/8-12	60-80 lb ft

ALUMINUM OR STEEL UNIONS

5/16-24	18-25 lb in.
7/16-20	55-80 lb in.
9/16-18	100-150 lb in.
3/4-16	200-300 lb in.
1 1/16-12	420-600 lb in.
1 5/16-12	50-70 lb ft

PLUGS OR CAPS

5/16-24	10-16 lb in.
7/16-20	40-65 lb in.
9/16-18	80-120 lb in.

Plugs using copper or aluminum asbestos gaskets:

- Tighten plug to required torque.
- Loosen and retighten to required torque.

Thread Size	Torque
HOSE CLAMPS	
Initial installation	10-15 lb in.
Retightening	10-15 lb in.

PACKING COUPLING NUTS

1/2-24	35-40 lb in.
5/8-18	150-200 lb in.

2-69. MAINTENANCE OF ENGINE COMPONENTS.
(See figure 2-1.)

2-70. ACCESSORIES CASE.

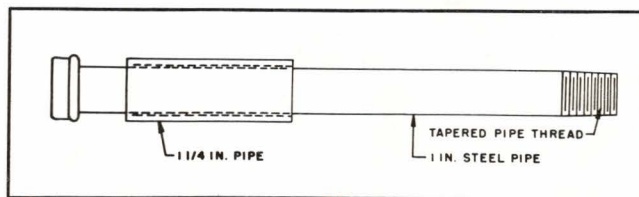
2-71. The engine-driven accessories are mounted on the accessories case on the front of the engine. These are the starter, main fuel control, tachometer generator, fuel pump, oil pump, and starting fuel control; there are spare pads for mounting aircraft accessories. The starter drives the rotor and accessories through gears and an overriding clutch. During an engine start, the starter turns the rotor until the unit is self-supporting; then the clutch pawls disengage. The lubricating oil reservoir is contained within the accessories case. The forward engine mount fastens to the accessories case.

2-72. **MAINTENANCE.** Follow this procedure to prepare a seal puller:

- Make a seal puller as shown in figure 2-7.
- Cut a standard pipe thread on the outside diameter of the pipe at both ends.
- Install a pipe cap on one end.
- Slide a one-foot length of one and one-quarter inch pipe over the one-inch pipe.
- Grind off any burrs from the inside diameter of the threaded end.

2-73. Remove seals in this manner:

- With the sliding section of the pipe installed on the seal puller, slide the threaded end of the one-inch pipe over the accessory drive shaft of the seal.
- Apply pressure with the palm of hand against the pipe cap, and thread the pipe approximately 3/8 inch into the seal metal case.
- Hold the pipe cap to steady the puller and slide the one-foot pipe section toward the engine to obtain maximum stroke.
- Rapidly slide the pipe section against the forward side of the pipe cap. Strike with as much force as possible in order to remove the seal with one stroke. Short repeated strokes bend the seal metal without removing it.



75135

Figure 2-7. Accessories Case Seal Removed

- e. Remove the seal spring from the accessory shaft.
- f. After the seal is removed, inspect the drive shaft and bearing for damage.

2-74. Use this procedure to install new oil seals:

- a. Apply a coat of lubricating oil to the drive shaft.
- b. Install the proper oil seal expander on the drive shaft and position the seal on the shaft. (See figure 2-8.) Remove the expander and drive the seal into position with the drift from tool group No. 1. (See figure 2-9.) A driver may be manufactured locally. (See figure 2-10.)

CAUTION

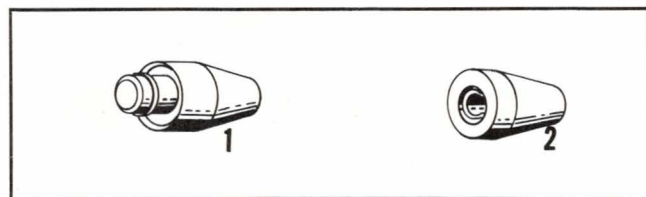
Take care not to fold the seal lip under the seal.
Do not drive the seal into the bearing cage deeper than shown in figure 2-10.

2-75. Use this procedure to check for upper idler gear looseness. (Tool Group No. 1.)

- a. Remove the fuel pump and the generator.
- b. Loosen the spline expanding screw on the fixture and install the fixture over four generator mounting studs so that the fixture engages the splines. (See figure 2-11.)
- c. When the splines have been engaged, tighten the spline expansion screw on the fixture until no axial movement of the tool is possible. Install the four mounting nuts to secure fixture.
- d. Use the same procedure to install the gauge on the fuel pump drive pad. (See figure 2-11.)
- e. Apply 400-500 pounds-inch torque counterclockwise to the gauge. More than 500 pounds-inch torque will damage the gauge spline.
- f. Reduce the torque on the gauge to 10 pounds-inch. Loosen the vernier screw and index the zero of the vernier scale with the zero of the protractor. Retighten the vernier screw.
- g. Apply 400-500 pounds-inch torque clockwise to the gauge. After the gear slip is felt, reduce the tension to 10 pounds-inch. Read the angular displacement on the scale.
- h. If the reading is more than 3° , remove the engine from service. If the reading is less than 3° , clean and lubricate the fuel pump and generator splines, and replace these accessories.

2-76. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{5}{16}$ -24	Bolts	Front support retaining	160-200 lb in.



1. Oil Seal Expanders No. 2947 and 2948
2. Tachometer Generator Oil Seal Expander No. 2827

Figure 2-8. Oil Seal Expanders

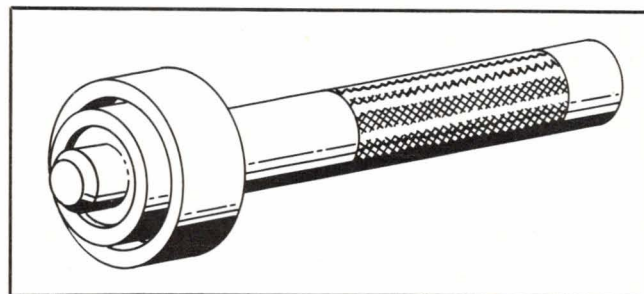


Figure 2-9. Accessories Oil Seals Drift No. 2980

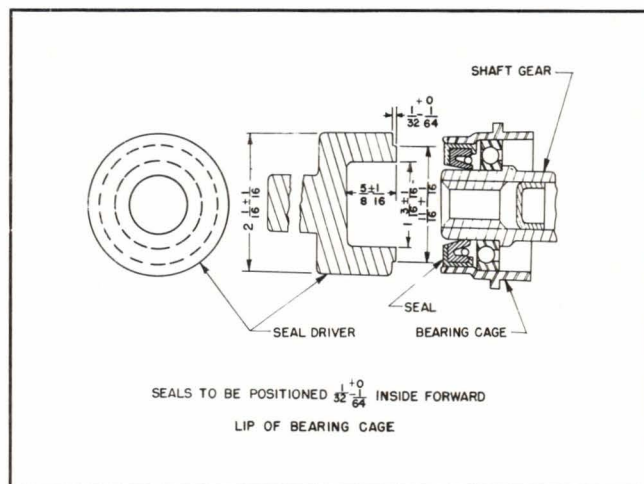
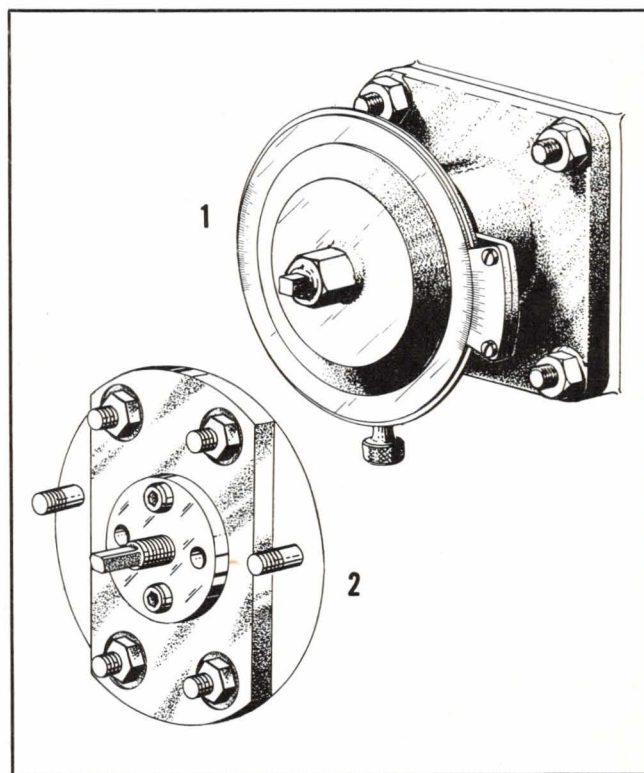
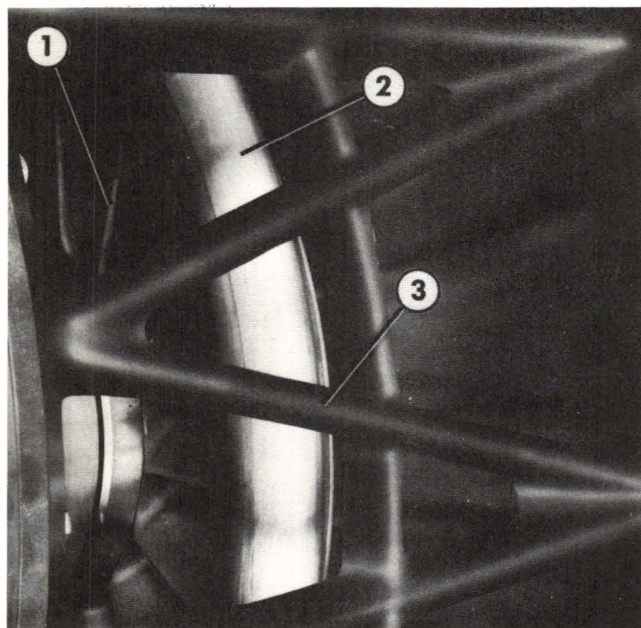


Figure 2-10. Accessories Case Seal Installation



1. Tool No. 6504
2. Tool No. 6505

Figure 2-11. Tools 6504 and 6505



81560M

1. Inducer Vane
2. Inlet Air Guide
3. Truss Ring

Figure 2-12. Compressor Inlet

2-77. COMPRESSOR.

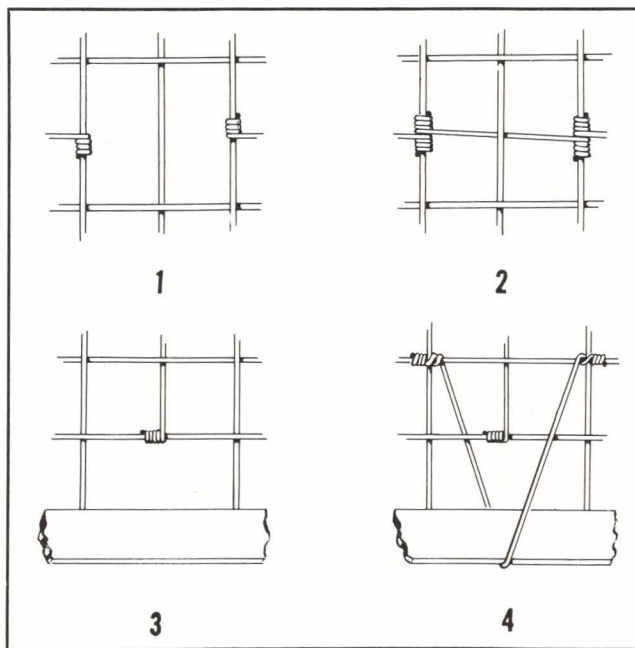
2-78. The double-entry, centrifugal compressor, located between the two compressor casing halves, is enclosed by the diffuser. Rotating inducer vanes are bolted to the front and rear face of the compressor impeller. Air enters the compressor duct formed by the front guide vane and the front bearing housing and by the duct formed by the rear guide vane and the rear bearing support. Truss rings support the compressor between the accessories housing and the ring and tube. Inlet screens are attached to the truss rings. (See figure 2-12.)

2-79. AIR INLET SCREENS.

2-80. The compressor inlet is protected from foreign objects by screens.

2-81. REMOVAL.

- a. External screens may be removed.
- b. Drain the oil from the engine by removing the magnetic drain plug from the bottom of the accessories case.
- c. Remove the main oil tube by loosening the tube nuts on each end of the oil tube and lifting the tube from the engine. Cap the openings in the engine and the tube.
- d. Disconnect the scavenge hose at the connection on the front of the accessories case. Cap the openings in the engine and the hose.
- e. Disconnect the ignition leads at the exciter.
- f. Remove the clamps which support the thermocouple lead.



82524

1. Unweave the broken wire back to a cross-wire. Wrap the wire.
2. Install lockwire. Solder the wraps.
3. Unweave ends of broken wire to a cross-wire. Wrap the wire. Solder securely.
4. Whipstitch the lockwire. Solder all wraps.

Figure 2-13. Air Inlet Screen Repair

g. Remove the screws which secure the thermocouple lead to the receptacle mounting bracket and place the lead over the top of the compressor.

h. Remove the fuel manifold.

i. Remove the screws which secure the screens together. Remove the screws from the rim of each screen and remove the screens from the engine.

j. To remove the aft screens, remove the air adapters and spacers. (Refer to paragraph 2-105.)

2-82. MAINTENANCE.

a. Repair broken wires in air inlet screens with 0.032-inch diameter stainless steel lockwire. (See figure 2-13.)

b. Broken wires may be repaired as often as necessary, but the ends of repair wire may be anchored only to original screen wire and must not be anchored to other repair wire.

c. Use only soft solder over wrapped wire. (Refer to paragraph 2-24.)



Ventilate the area while soldering.

d. Patch holes in inlet screens. Unweave the edges of the patch, bend the fringe down, and place it over the hole so that the patch is supported on each side by two strands of the original screen. Wrap the wires of the patch around the screen and secure with soft solder.

TABLE V

Compressor Inducer Vane Inspection Limits

Item	Number	Limit	Disposition
Nick or dent in outer two-thirds of leading edge.....	Any	1/8 inch deep 1/8-3/16 inch deep Over 3/16 inch deep	Continue in service Blend* Remove engine
Nick or dent in inner one-third of leading edge.....	Any	1/16 inch deep 1/16-1/8 inch deep Over 1/8 inch deep	Continue in service Blend* Remove engine
Bent vanes without cracks.....	Any	None permitted	Remove engine
Cracks in vanes.....			Remove engine

*Remove the engine if it does not have external screens.

2-83. INSTALLATION. Install in reverse of removal.

2-84. COMPRESSOR INDUCER VANES.

2-85. The compressor inducer vanes are bolted to the front and rear faces of the compressor impeller. The fixed guide vanes shroud these vanes so that the air must enter the compressor through them.

2-86. INSPECTION. Inspect vanes to the limits shown in table V. (See figure 2-12.)

2-87. MAINTENANCE. Repair damaged vanes that are within blend limits:

- Make depth of the final blend $\frac{1}{16}$ inch greater than the original nick or dent.
- The length of the final blend should be six times the final depth.
- Edges of the blend should be rounded.
- Operate the engine after blending and check for vibration from impeller unbalance.

2-88. FIXED INLET GUIDE VANES.

2-89. The fixed inlet guide vanes cover the forward and aft faces of the impeller and form part of the duct through which the air must enter the compressor. (See figure 2-12.)

2-90. INSPECTION.

- Only one crack is permitted at each screw hole.
- A crack from the screw hole toward the rolled edge must not be longer than $1\frac{1}{8}$ inches; three cracks are allowed.
- A crack from the screw hole toward the mounting flange may be any length; three cracks are permitted.
- Drill a $\frac{1}{8}$ -inch hole at the end of each crack to stop it.
- Tighten loose screws and peen them if the engine has external screens.
- If the screws are still loose, replace them. If the new screws cannot be tightened, replace the engine.
- On engines with internal screens, replace the engine if the screw head is worn or if the screw hole is enlarged.
- Cracks in the rolled edge are permitted up to $\frac{3}{4}$ inch long, provided there are not more than two cracks

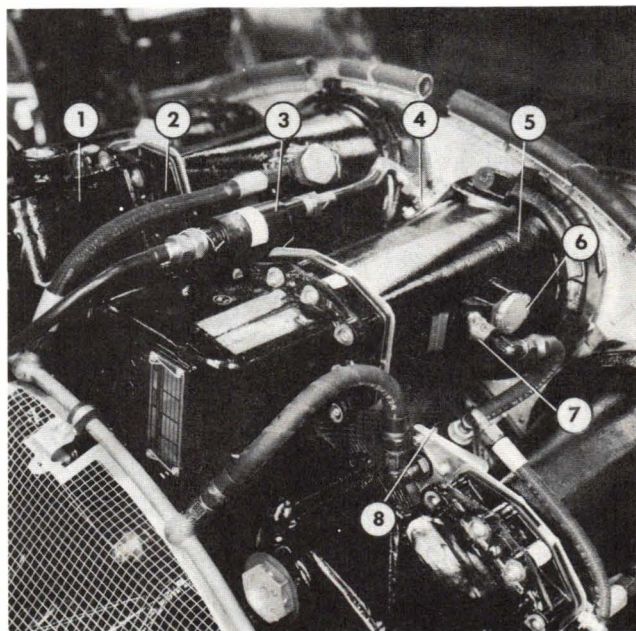
not closer than 90 degrees to each other. Drill a $\frac{1}{8}$ -inch hole at the end of each crack to stop it. If at a later inspection the crack has progressed beyond the stop hole, replace the engine.

2-91. TORQUE LIMITS.

Size	Name	Location	Torque
8-32	Screws	Fixed guide vane mounting	30-35 lb in.

2-92. DIFFUSER.

2-93. The diffuser surrounds the compressor impeller and controls the expansion of the compressed air through its turning vanes to the aid adapters. (See figure 2-14.)



81562

- | | |
|-------------------------|------------------------------|
| 1. Diffuser | 5. Air Adapter |
| 2. Air Adapter Spacer | 6. Fuel Filter Plug |
| 3. Ignition Transformer | 7. Fuel Inlet Elbow |
| 4. Igniter Plug | 8. Starting Fuel Check Valve |

Figure 2-14. Air Adapter Installation

2-94. MAINTENANCE.

2-95. Inspect the compressor diffuser turning vanes for looseness within the following limits. Complete looseness is in the direction of air flow.

a. Maximum complete looseness of any two vanes per port is 0.065 inch, provided the remaining vanes do not exceed 0.020 inch complete looseness.

b. Maximum looseness at one end of vane is 0.075 inch if the other end of the vane is tight.

2-96. Check the split line between the compressor case and the diffuser for leaks. Check the splitline clearance on both sides of the engine and between the two trunnion mounting bushings on each side of the engine. Replace the engine if a 0.015-inch feeler gauge can touch the compressor case pilot flange at any location.

2-97. Inspect compressor shims for protrusion. If shims protrude more than $\frac{3}{8}$ inch, replace the engine. If shim protrusion is within the limit, tighten the diffuser studs.

a. Retighten diffuser stud nuts by tightening all nuts to a maximum of 275 pound-inches.

b. Loosen one nut at a time and retighten it to 150-220 lb in.

2-98. A broken diffuser air adapter mounting flange is serviceable if not more than $\frac{1}{3}$ of the bolt bushing is exposed. One break per adapter is allowed. The flange bushing must be secure and the bolt must be lockwired to an adjacent bolt.

2-99. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{1}{16}$ -12	Plug	Diffuser	200-360 lb in.

2-100. TRUSS RINGS.

2-101. The truss rings are attached to the front and rear bearing supports and to the diffuser. Air enters the compressor through the open areas of the truss rings. (See figure 2-12.)

2-102. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{5}{16}$ -18	Set screw	Trunnion spindle	100-110 lb in.
$\frac{3}{8}$ -24	Nut	Truss ring retaining	
		a. Tighten to 275 lb in.	
		b. Loosen each nut and re-tighten it to 150-220 lb in.	
$\frac{3}{4}$ -16	Bolt	Trunnion spindle	100-110 lb ft

2-103. AIR ADAPTERS.

2-104. Fourteen air adapters direct the passage of air from the diffuser to the combustion section. The fuel nozzles and igniter plugs are mounted in the air adapters. The air adapters are numbered clockwise when looking at the engine from the rear; No. 1 is on the top right of the vertical center line. (See figure 2-14.)

2-105. REMOVAL. (Tool Group No. 2.)



45862

Figure 2-15. Flexible Extension No. 3613

Note

Use temporary covers to keep foreign material out of the engine.

a. Disconnect the drain manifold coupling nuts from the fittings on No. 5, 6, 7, 8, 9, 10, and 11 air adapters. Remove the drain manifolds.

b. Remove the main fuel manifold coupling nuts from No. 7 and 14 starting fuel manifold check valves. Disconnect the starting fuel system hose at each starting fuel manifold check valve. Remove the check valves. Remove the remaining fuel manifold coupling nuts from the air adapter elbows.

c. Remove the igniter plugs.

d. Remove the bolts and washers which secure each air adapter and spacer to the diffuser; use the special tool. (See figure 2-15.) Remove the air adapter spacer and gaskets. Discard the lockwashers and gaskets. Slide the air adapter forward and remove it.

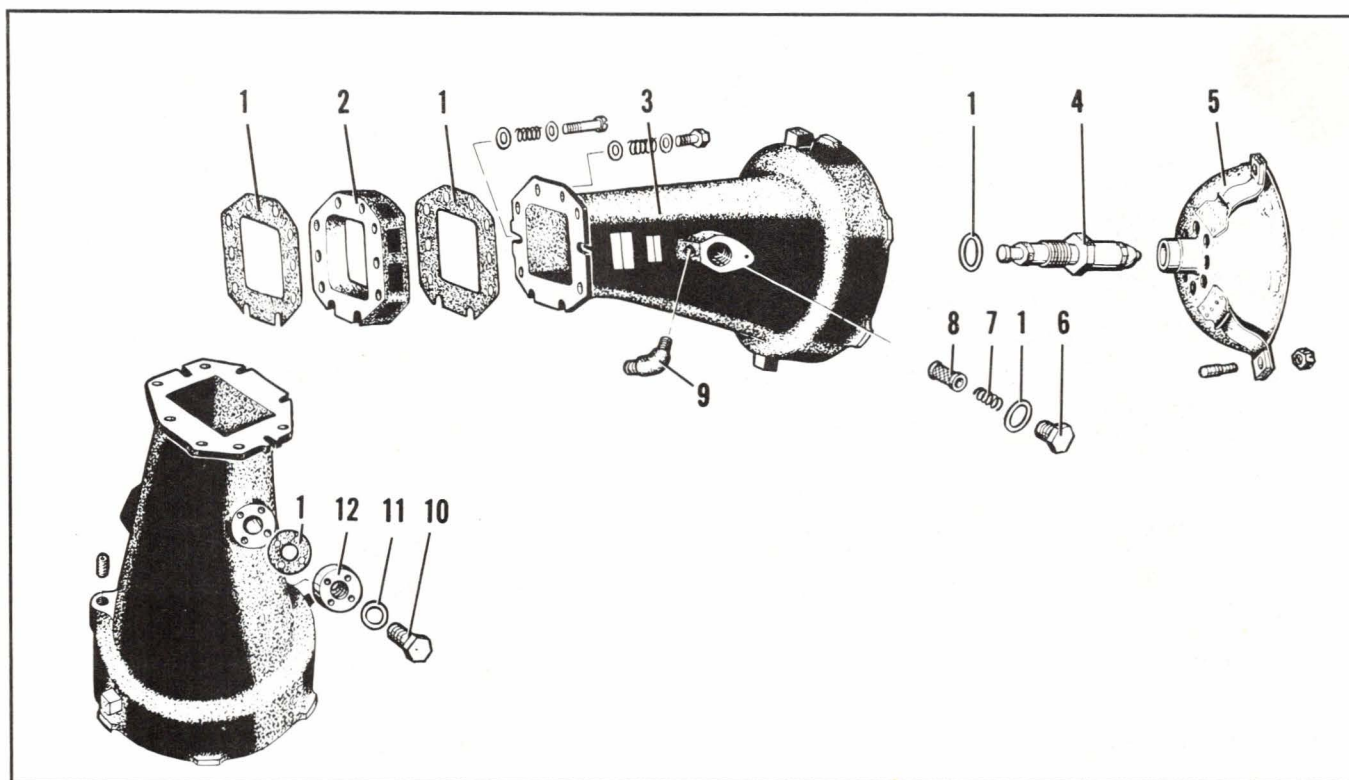
2-106. DISASSEMBLY. (See figure 2-16.)

a. Remove the nuts securing the combustion dome brackets to the adapter. Remove the dome, carefully lifting it over the nozzle tip.

b. Remove the hexagonal head plug, gasket, and filter retaining spring. Discard the gasket.

c. Insert the puller in the open end of the tubular filter and rotate the handle slightly in either direction to free the filter in the housing. Remove the filter. (See figure 2-17.)

d. Remove the fuel nozzle and gasket, being careful not to damage the nozzle orifice and filter screen. Discard the gasket.



32377

1. Gasket
2. Spacer
3. Air Adapter
4. Fuel Nozzle

5. Dome
6. Fuel Filter Plug
7. Spring
8. Fuel Filter

9. Fuel Inlet Elbow
10. Vent Cover Bolt
11. Washer
12. Vent Cover

Figure 2-16. Air Adapter Details

2-107. **CLEANING.** Clean air adapters, domes, fuel filters, and fuel nozzles. (Refer to paragraph 2-211.) Inspect for cracks and evidence of bad welds. Replace faulty fuel nozzles. (Refer to paragraph 2-211.)

2-108. **INSPECTION.** Inspect the domes after cleaning:

- a. Inspect the inside surface of the dome opposite the bracket spot welds. Replace any domes with cracks.

- b. Inspect both edges of each dome bracket at the bracket washer. Replace any domes with cracked brackets.

2-109. **ASSEMBLY.**

- a. Coat the threads of each fuel nozzle with a light coat of the lubricant specified in paragraph 2-212, and install the nozzle and a new gasket. (See figure 2-18.) Tighten to torque specified in paragraph 2-213.

- b. Carefully place the dome in position over the fuel nozzle and secure with nuts. (See figure 2-19.) The fuel nozzle must protrude from the aft end of the dome sleeve or be flush with it. If it is not, replace the dome or bend the brackets to position it correctly.

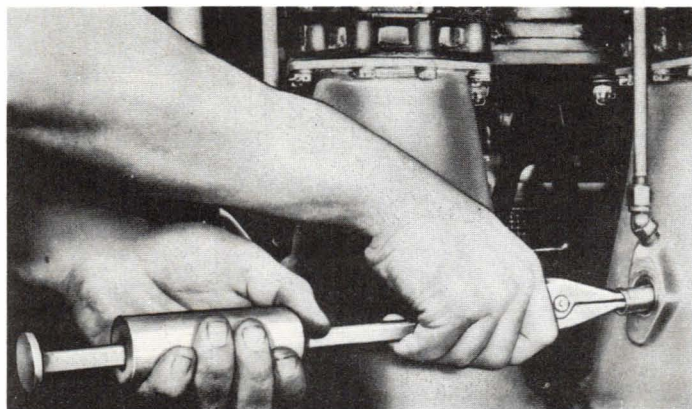
- c. Install the tubular filter, retaining spring, a new gasket, and hexagonal head plug. Coat plug threads and gasket with Permatex No. 3 and then tighten the plug. Coat threads of the fuel inlet elbows and drain fittings with Permatex No. 3.

2-110. **INSTALLATION.**

Note

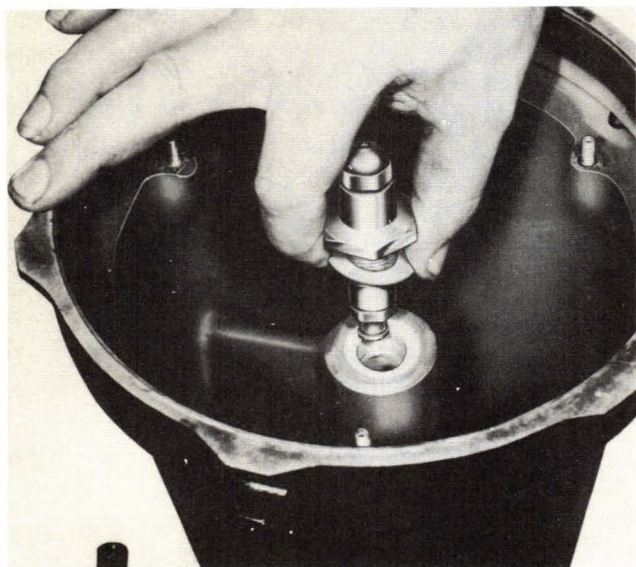
The fourteen air adapters are numbered; install them at the diffuser elbows with corresponding numbers.

- a. Install the compression rings by hand in the combustion chamber ring grooves. Position the rings so that their gaps are above the horizontal center line of the tube opening and at least 60° apart before the air adapter is installed.



26113

Figure 2-17. Air Adapter Fuel Filter Puller No. 9074026



30323

Figure 2-18. Installing the Fuel Nozzle



30038

Figure 2-19. Installing the Dome

b. Install the air adapters. Press the recessed end of the adapter over the compression rings; turn the adapter at the same time. The flared edge of the adapter recess will compress the rings, allowing the adapter to slide into position. Rotate the adapter until it is in the proper position for installation of the spacer.

c. Place a new gasket on each face of the spacer and install the spacer so that index marks line up. (See figure 2-20.) Using a new lockwasher, install the bolts and washers. Apply the lubricant in paragraph 2-30.

Note

Put the plain washer against the spot face of the diffuser and put the lockwasher between the plain washer and the head of the bolt.

d. Install the drain manifolds. Apply Permatex No. 3 to drain fitting pipe threads.

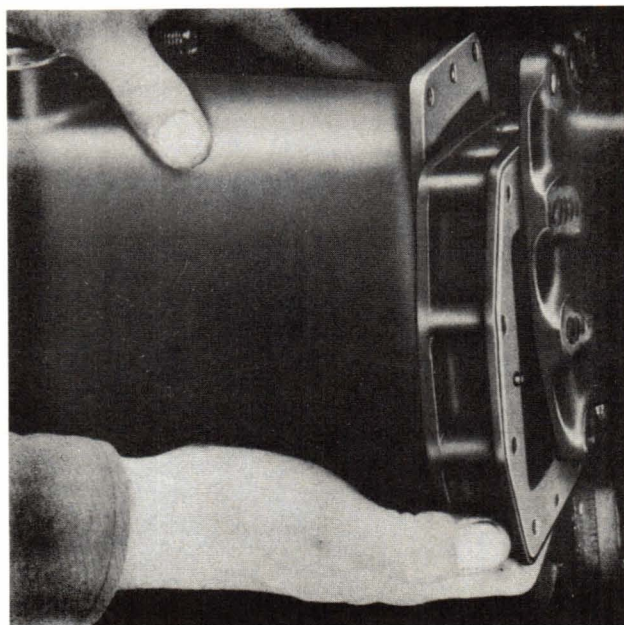
e. Install the lines to the combustion chamber check valves. Install the main fuel manifold coupling nuts and the starting fuel hose. Apply Permatex No. 3 to the fuel inlet elbow threads.

f. Install the igniter plugs.

2-111. TORQUE LIMITS.

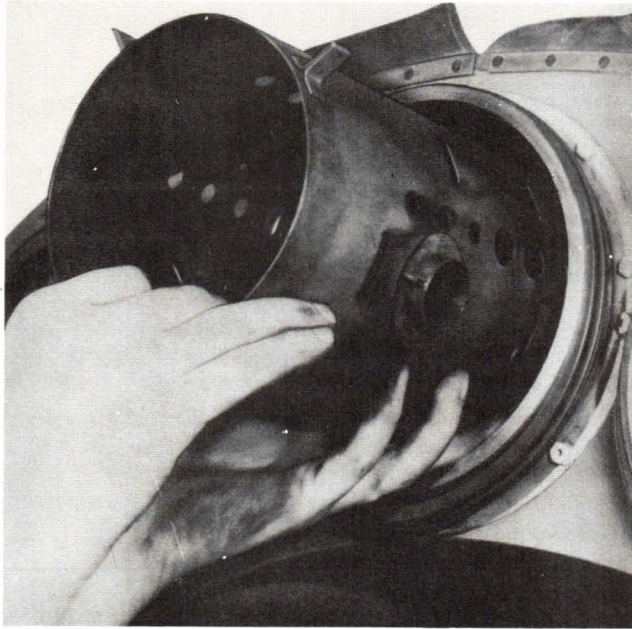
Size	Name	Location	Torque
10-32	Nuts	Dome-to-air adapter	
		a. Tighten to 40 lb in. to seat parts.	
		b. Loosen until the dome is free to move.	
		c. Center the dome in the air adapter.	
		d. Tighten to 35-45 lb in.	
		e. The clearance between air adapter ID and dome OD must be equal within 0.010 inch at three points 120° apart.	
1/4-28	Bolts	Retaining air adapter brackets and inner air baffle sectors to the tube flange	50-60 lb in.

Size	Name	Location	Torque
1/4-28	Bolts,	air adapters and spacers to compressor diffuser:	
		a. Draw down evenly and lightly to obtain contact with gasket; tighten locating bolts on sides first.	
		b. Apply increased tension to approximately 30 lb in. torque.	
		c. Apply final tension to 50-60 lb in., measured on bolts that are accessible to torque wrench.	
7/16-20	Bolt	Instrumentation	100-125 lb in.
7/8-14	Plug	Filter	60-80 lb ft



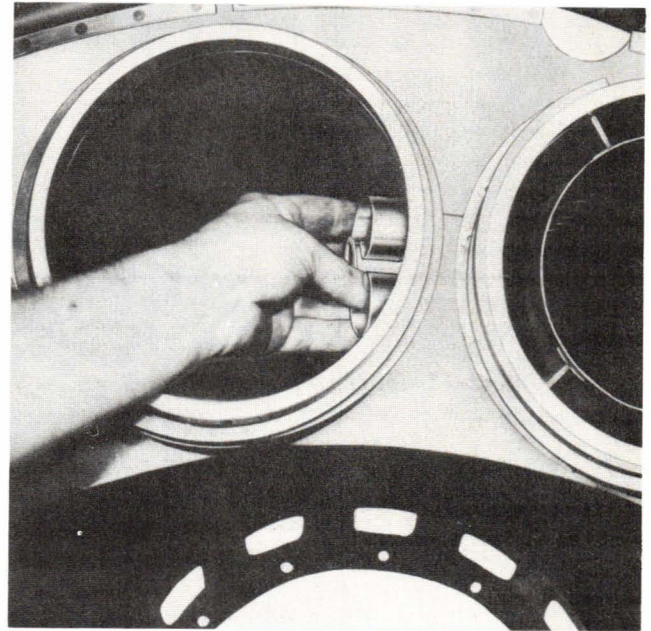
29978

Figure 2-20. Installing the Air Adapter Spacer



27710

Figure 2-21. Removing the Inner Liner



30040

Figure 2-22. Removing the Crossover Tube

2-112. RING AND TUBE.

2-113. Fourteen outer combustion tubes are welded to a supporting ring. Inner liners fit within these tubes, and the turbine shroud is bolted to the supporting ring. (See figure 2-28.)

2-114. INSPECTION.

2-115. Remove the exhaust unit and turbine shroud. While the turbine blades are removed for the turbine wheel serration crack inspection, use a strong light to examine the gusset plate-to-ring corner welds. Four cracks within $\frac{3}{4}$ inch of the ring-to-gusset plate junction are allowed, provided at least two uncracked gussets separate cracked ones. Cracks not at the corners are allowed up to $\frac{3}{4}$ inch long, one to each side of a compartment, provided no compartment has more than two cracks.

2-116. Remove the engine if serious chafing of a combustion chamber by adjacent parts might fracture the chamber wall. Do not remove the engine because of cracks in the chamber wall near the ring and tube aft flange unless there are carbon deposits in the cracks or on the surface of the chamber.

2-117. Remove the engine if cracks in the outer combustion chamber are more than one and one-half inches long and are less than one-half inch apart. Remove the engine if shorter cracks or more widely-spaced cracks have soot or carbon deposits.

2-118. MAINTENANCE. Repair cracks within the limits with metallic arc welding. (Refer to paragraph 2-28.)

2-119. INNER LINERS.

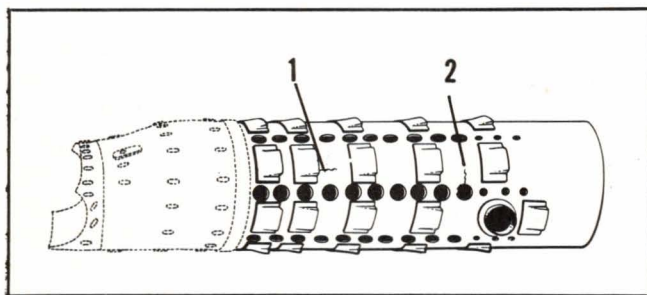
2-120. Combustion takes place in fourteen inner liners. These liners have removable domes; the igniter plugs and fuel nozzles fit into them. Fuel which may accumulate when the engine is shut down drains from the upper combustion chambers through the burner chamber rear section to chambers No. 5 and 11 and into a drain manifold. Combustion chambers No. 6-10 connect to the drain manifold. The drain manifold is connected by an aircraft-furnished hose to the combustion chamber drain valve, which empties the manifold after an unsuccessful start or after stopping the engine.

2-121. REMOVAL.

- a. Remove the aid adapters. (Refer to paragraph 2-105.)
- b. Straighten the tab washers under the inner liner positioning bolts on the outside of the combustion chambers near the exhaust end. (See figure 2-28.) Remove the dowel bolts.
- c. Remove the inner liners. (See figure 2-21.)
- d. Slide the inner crossover tubes and spacer springs out of position. (See figure 2-22.)

2-122. INSPECTION.

- a. Whenever air adapters are removed, inspect the inner liners. In case any inner liner is replaced, record the engine position of the replaced liner and the hours since last overhaul at time of replacement.
- b. Replace inner liners with cracks larger than the limits in figure 2-23.
- c. Replace inner liners with pieces broken out.
- d. Replace badly burned or severely buckled liners.
- e. Replace liners with cracks which may result in a piece breaking out from crack progression.



58103M

1. Louver crack 1 inch
2. Hole crack 1 inch

Figure 2-23. Inner Liner Inspection Limits

f. Inspect the inner area of the exhaust cone for heat streaks or excessive warping. The location of heat streaks on the inner surfaces of the exhaust cone indicates approximately the location of the combustion chamber with a faulty nozzle or a faulty inner chamber. If evidence indicates that a combustion chamber has been malfunctioning, remove the engine from the aircraft, remove all air adapters, and inspect all inner liners, domes, and nozzles.

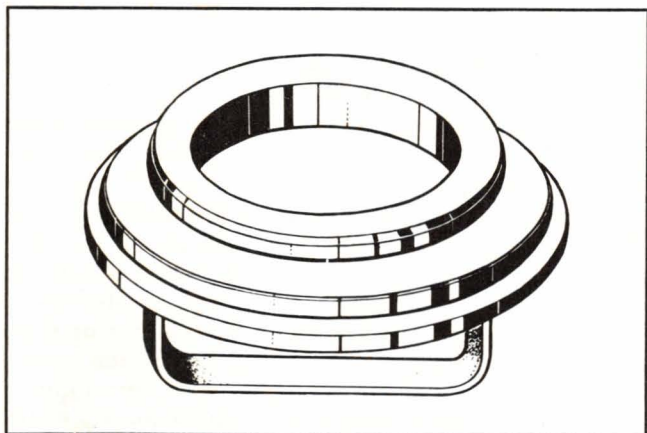
g. Replace the inner liner if any cracks are found in the transition section of the liner.

h. Replace the inner liner if spacers or locating pads on the transition end are worn thinner than 0.035 inch.

i. If the inner liner positioning bolt hole is elongated, weld it closed and grind the weld flush with the surrounding surface.

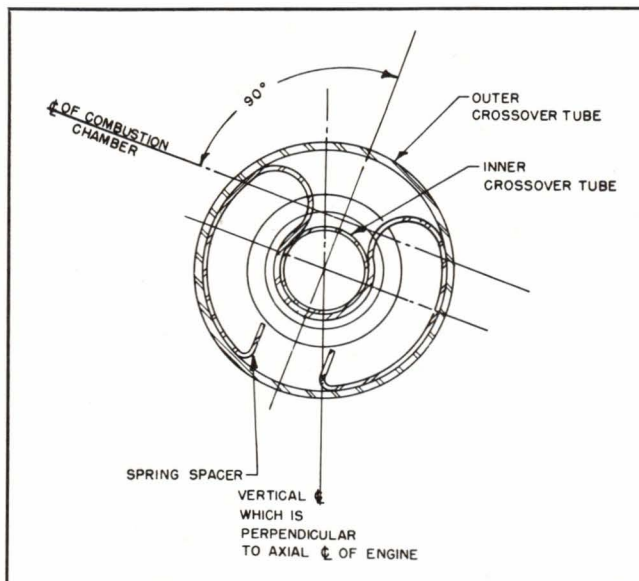
2-123. INSTALLATION. (Tool Group No. 9.)

a. When installing an inner liner in a combustion chamber of the ring and tube, locate the inner liner axially in the combustion chamber; in order to avoid incorrect assembly of the dome in the end of the inner liner, center the front end of the inner liner in the combustion chamber tube of the ring and tube assembly. Use the gauge to center the front end of the inner liner in the combustion chamber tube and to engage the axial position of the inner liner. (See figure 2-24.)



59619

Figure 2-24. Inner Liner Centering Gauge No. 3144



55558

Figure 2-25. Crossover Tube Spring Spacer Installation

b. Install the odd-numbered liners first.

c. Install the gauge into the inner liner so that the front edge of the inner liner is seated firmly against the shoulder of the tool. The entering edge of the tool contains a chamfer which will guide an out-of-round liner into the pilot diameter of the tool.

d. Insert the inner liner into the combustion chamber tube of the ring and tube assembly. Using the gauge and tapping lightly with a mallet if necessary, seat the inner liner so that the flange of the tool bottoms against the combustion chamber tube of the ring and tube.

e. With the gauge held in position, mark the location of the positioning bolt hole on the elongated pad of the inner liner. Remove the inner liner from the combustion chamber tube. Drill through and use a lead pilot reamer to ream a hole 0.181-0.183 inch in diameter for the positioning bolt at the marked position.

f. Coat the threads of the inner liner positioning bolt with Ab-lube. Re-install the inner liner into the combustion chamber tube, using the tool to center the front end of the inner liner radially in the combustion chamber tube while the positioning bolt is being tightened.

g. After the positioning dowel is secured, remove the tool from the combustion chamber tube, being careful not to disturb the centered position of the inner liner.

h. Install the inner crossover tube in the inner crossover tube spring spacer. Position the spacer so that its two edges are equidistant from the ends of the tube.

i. Install this assembly in the outer crossover tube, and position the spacer so that the center line of the opening between the ends of the spring spacer is located 90° from the axial center line of the combustion chamber bore and pointed in the direction of the axial center line of the engine. (See figure 2-25.) The ends of the inner crossover tube should protrude equally into the bores of the adjacent outer combustion chambers.

j. Install the even-numbered liners.

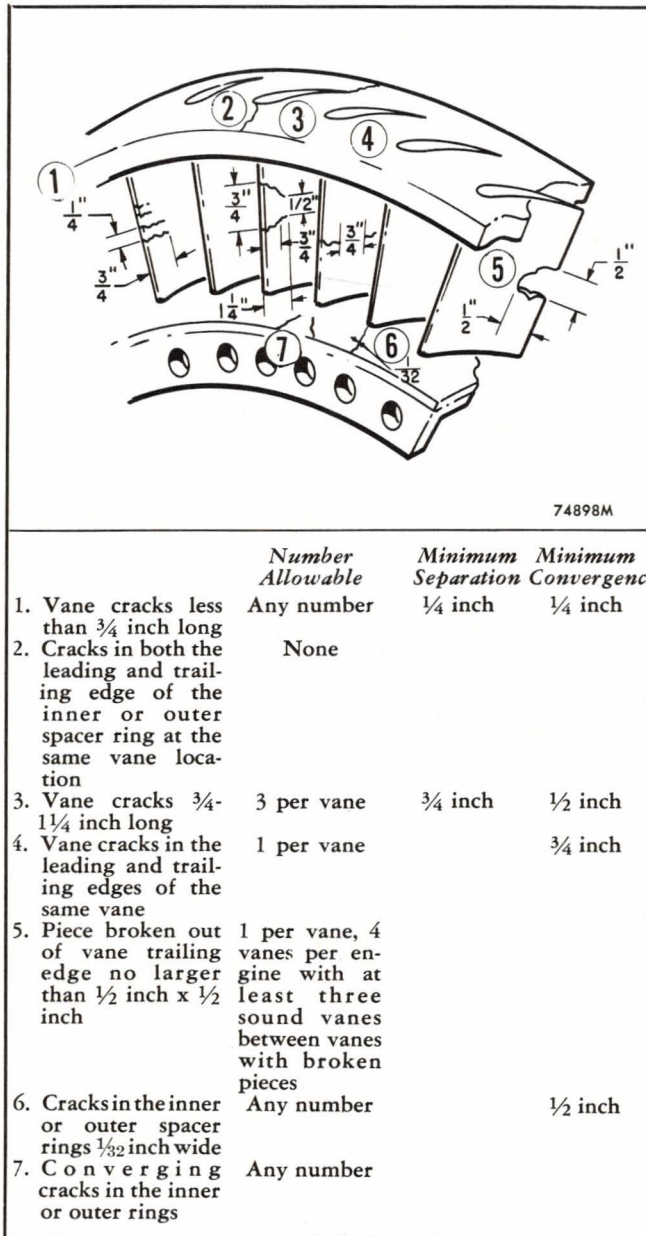


Figure 2-26. Turbine Nozzle Inspection Limits

k. Install the locking clips and dowel bolts which secure the inner liners. Lock the tab washers.

1. Install the air adapters. (Refer to paragraph 2-110.)

2-124. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{1}{4}$ -20	Bolt	Inner liner positioning	45-60 lb in.

2-125. TURBINE NOZZLE.

2-126. The turbine nozzle, located in the rear of the ring and tube, is two concentric spacer rings supporting a circle of vanes which direct the gases against the turbine wheel blades. Exhaust gases are prevented from overheating the rear turbine bearing by a baffle riveted to a third ring which supports the nozzle in the turbine unit.

2-127. INSPECTION.

2-128. Inspect the turbine nozzle spacer-ring-to-flange weld. If the nozzle contains no pins and exceeds 200 hours operational time or if the nozzle is cracked, replace the nozzle or reject the engine. (Refer to Section V.) If the nozzle is a pinned one, it may have cracks 360° around the weld; it may be continued in service until the engine is sent to overhaul. See figure 2-26 for crack limits in the spacer. Reject the engine if any crack is wider than $\frac{1}{32}$ inch or if the cracks emanate from both the leading and trailing edge of the same vane.

2-129. Inspect the turbine nozzle vanes:

a. There is no limit to the number of distorted vanes nor to the size of distortion. Replace the engine only if performance is affected adversely.

b. If a dent does not affect engine performance it is acceptable. If cracks emanate from a dent apply the crack limits in figure 2-26.

c. Replace the engine if any vane has a nick deeper than $\frac{1}{8}$ inch. Any number of nicks less than $\frac{1}{8}$ inch are acceptable.

2-130. Make a turbine nozzle inner ring position gauge:

a. Use MIL-S-6054, MIL-S-6758, or AN QQS690 material. (See figure 2-27.) Harden and draw to 42-46 Rockwell after forming.

b. Form the 45° angle first; then form the 30° angle.

2-131. Determine the fore and aft position of the turbine nozzle inner ring by inserting the gauge between the leading edge of the inner ring and the ring and tube mounting flange face at 8 or more equally-spaced positions. If the gauge blade will enter any position so that the tip bottoms on the outer diameter of the mounting flange, reject the engine.

2-132. TURBINE.

2-133. The single-stage turbine is spline-coupled to the compressor. The turbine is supported by a bearing at each end of the shaft. Both bearings are housed in the turbine bearing support, which is bolted to the ring and tube. Blades are dovetailed and pinned into the turbine wheel. (See figure 2-28.)

2-134. MAINTENANCE. The turbine rotor does not need to be rebalanced. Field replacement of blades must be made with the wheel installed. Replace as many blades as necessary. Matched pairs of blades made of S-816 steel and GMR-235 alloy may be in the same wheel. Make a ground operational check for excessive vibration. Whenever more than 13 pairs—26 blades—are replaced, make a flight test. Mismatched blades can cause engine vibration. Examine each blade to see that it is properly matched. If there are two numbers on a blade, the bottom one must match the bottom number on its mate. If there is only one number with two or three digits, the number on the mating blade must match exactly. If there is only one number with four digits, it must match within five the number on the mating blade. Remove the engine if excessive vibration occurs after blade replacement.

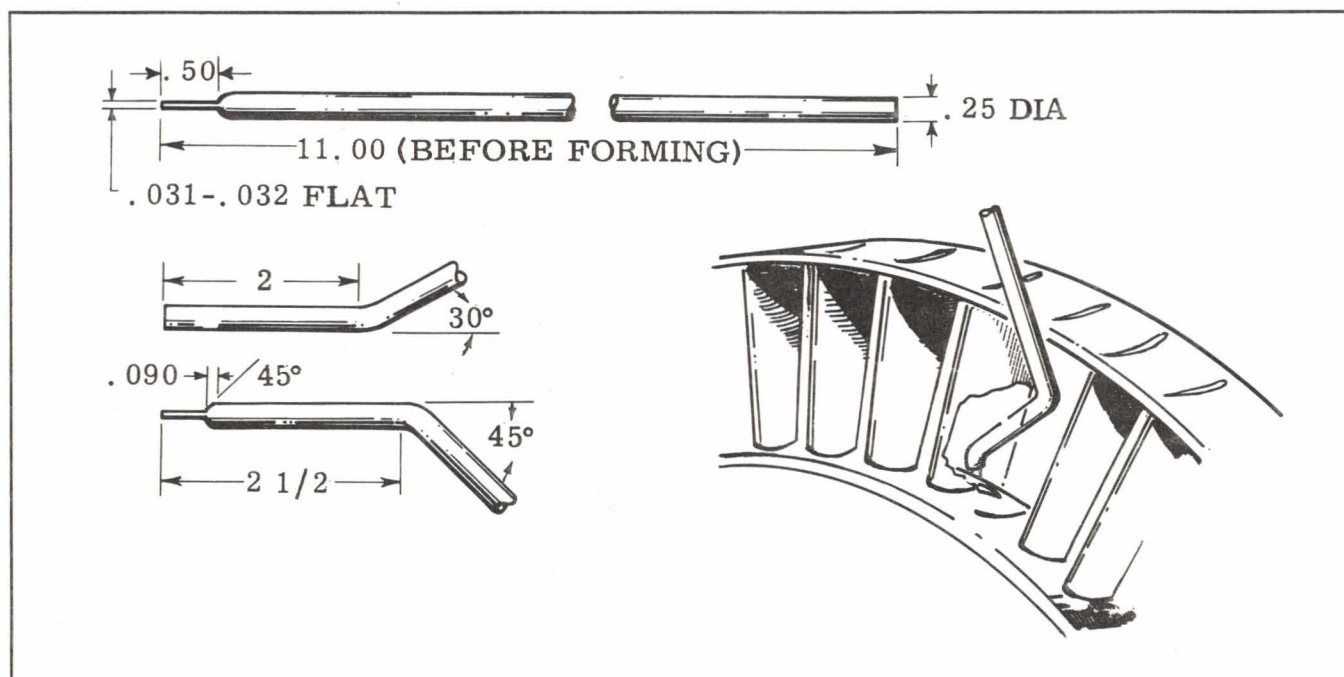


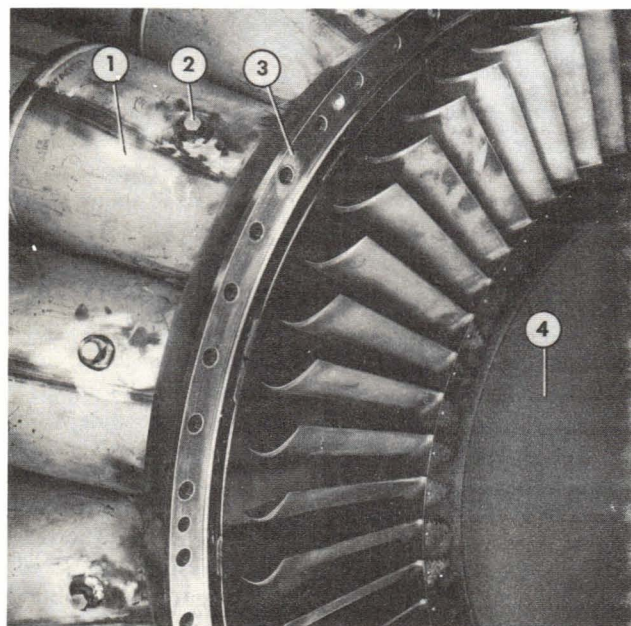
Figure 2-27. Turbine Nozzle Inner Ring Position Gage

101705

2-135. INSPECTION.

2-136. Inspect the turbine wheel and blades without removing the exhaust cone. (See figure 2-29.) Enter the tailpipe, and examine the turbine blades with a bright light. Check for rubbing or scraping of any surface of the turbine wheel against adjacent parts of the engine by pushing forward on the turbine wheel while slowly

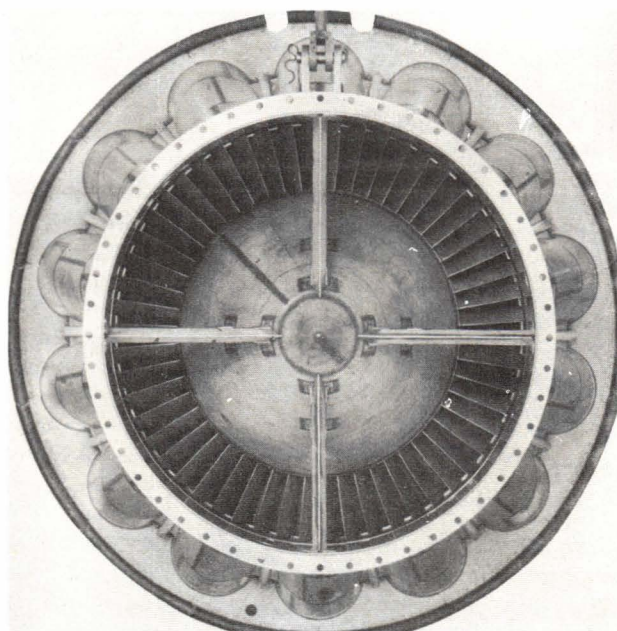
rotating it. Remove the engine if the turbine rubs against the gas baffle or nozzle inner ring. If there is any damage to the turbine blades, remove the exhaust cone (refer to paragraph 2-160) and make a closer inspection of the turbine blades and nozzle vanes. (See figures 2-26 and 2-30.) Examine all surfaces of the blades with a strong light.



81568

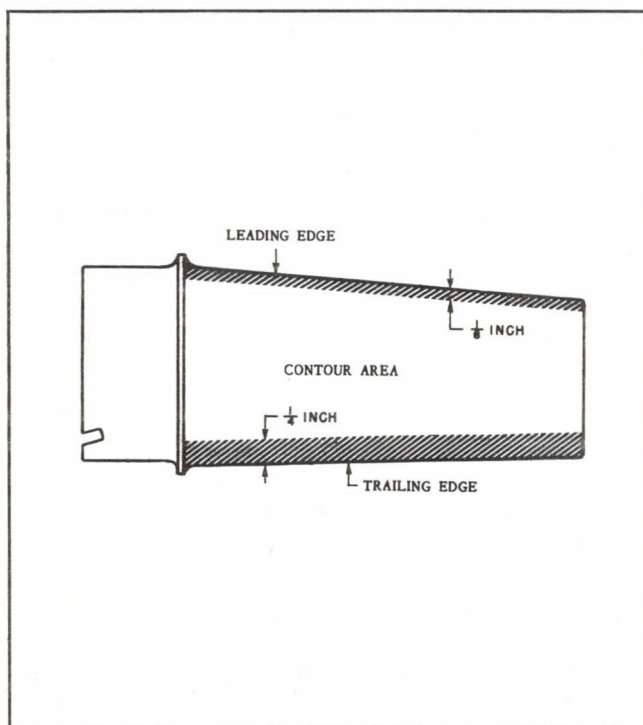
1. Outer Combustion Tube
2. Inner Liner Positioning Bolt
3. Exhaust Cone Mounting Flange
4. Turbine Wheel

Figure 2-28. Turbine Wheel



63338

Figure 2-29. Turbine Wheel—Exhaust Cone Installed



59709

Location of Damage	Maximum Number Nicks and Dents	Maximum Depth or Length
Leading edge	No limit	0.015 inch deep
Contour area	No limit	0.015 inch deep
Trailing edge	None permitted	
Blade tip end scuffing or grooves		0.031 inch deep and half the length of the blade tip
Cracks in any location	None permitted	

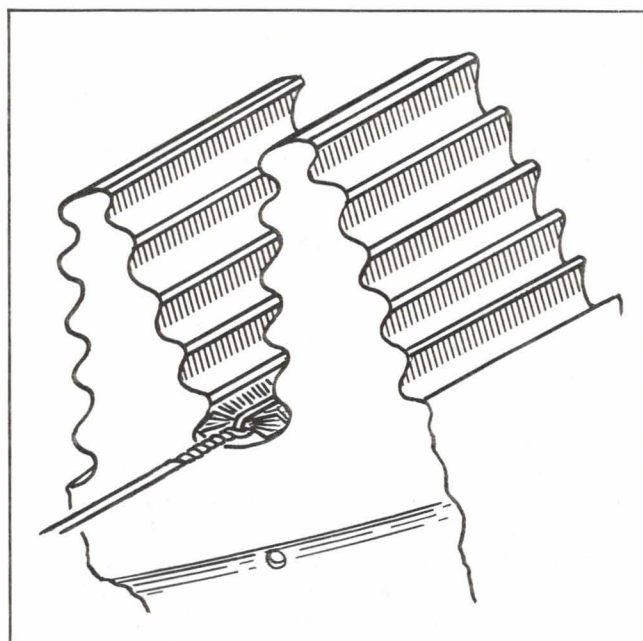
Figure 2-30. Turbine Blade Inspection Limits

2-137. Inspect the aft side of the turbine wheel for cracks. At each 120-hour inspection and whenever a blade is removed, inspect for cracks in the innermost two serrations of each blade slot using the following procedure; these cracks are caused by excessive speed and temperature.

CAUTION

Serration failure is serious; therefore, follow this procedure without deviation. Do not mistake bottom land cracks for serration cracks.

- a. Remove three pairs of blades approximately 60° apart.
- b. Position the turbine rotor with the serration to be cleaned on the side so that foreign material will not fall into the turbine bearing.
- c. Clean the serration with any approved solvent; dry with compressed air. Clean the opposite blade slot in the same manner.
- d. Place the serration wire brush in tool group 11 in the bottom of the blade slot with its width extending under the innermost two serrations.



113816

Figure 2-31. Cleaning Turbine Wheel Serrations with Brush No. 6795808

e. Grip the end of the brush handle firmly with a pair of pliers and move the brush fore and aft until powdered oxide or carbon particles are no longer extracted at each rearward stroke of the brush and until all carbon, varnish, or oxide deposits are removed to the bare metal. Brush the opposite blade slot in the same manner. (See figure 2-31.) The brush may be fastened in a sabre-type power hand tool.

Note

No substitute for the wire brush is permitted. A brush with plastic or hog hair bristles will not clean the serration.

f. Thoroughly clean the residue from the two blade slots with solution No. 1 solvent furnished with the dye-penetrant kit or with carbon tetrachloride. Dry with compressed air.

g. Apply the dye-penetrant solution to the bottom of the innermost serration of the two opposed blade slots with a small brush. Be sure that the entire area to be inspected is covered thoroughly with the dye-penetrant. Allow the solution to dry three to ten minutes without moving the turbine rotor.

h. Rotate the turbine rotor 180° and repeat step g.

i. Repeat steps b through h above on each of the other two pairs of opposed blade slots to be inspected.

Note

Do not allow the penetrant to dry completely before removal. If penetrant does dry completely, apply more penetrant to the area and remove immediately. Do not use solution No. 1 to remove the penetrant.

j. Remove the dye-penetrant completely with a soft cloth or cotton swab.

k. Vigorously shake the developer solution supplied with the dye-penetrant kit. Apply the developer to the area to be inspected using an air spray gun or a small brush.

Note

Use only a very thin coat of developer. This may be accomplished by blowing all excess developer from the serration immediately after application.

l. Allow five minutes for the dye from any crack to bleed into the developer.

m. Examine the underside of the innermost serration for evidence of cracks by using a bright light (source at the wheel perimeter) focused on the bottom of the blade slot. View the serration to be inspected from a point approximately 10° below an imaginary line through the serration being inspected. (See figure 2-32.) Pay particular attention to the innermost portion of the serration recess. Any crack indication—a distinct red line or light dotted red line—is cause for rejection.

2-138. Remove the engine to class C maintenance for turbine wheel replacement if these limits are exceeded:

a. Remove the engine if any crack extending forward from the pin hole is longer than $\frac{5}{32}$ inch or extending aft from the pin hole reaches the wheel rim rear face.

b. Remove the engine if a crack of any length on the front or rear wheel rim face emanates from the bottom land of the blade slot.

c. Remove the engine if any crack not associated with the pin hole or the front face is longer than $\frac{1}{2}$ inch.

2-139. Inspect the turbine blades:

a. Replace any bent, cracked, or broken blade. Any crack on the blade surface or on the leading or trailing

edges makes replacement necessary. Examine the trailing edges of the blades where rubbing occurs with a magnifying glass.

b. Replace any blade with nicks or dents in the trailing edge.

c. Replace any blade with nicks or dents in the leading edge or contour area which show through to the opposite side.

d. Replace any blade with nicks or dents deeper than 0.015 inch.

Note

Make blade replacements only in matched pairs. Do not attempt to match blades in the field. Should one blade in a matched pair become defective, send the other blade to overhaul.

e. Replace any blade stretched beyond 0.015 inch. Use the radial stretch gauge from tool group No. 14 to check for stretch when the tip clearance is below minimum. (See figure 2-33.)

f. Any scuffing which causes bending of blades or causes cracks to start is cause for blade rejection. Normal operation causes both the leading and the trailing edges of all blades to curve. Compare a badly scuffed blade with the other blades in the turbine wheel or with blades in a satisfactory engine with approximately the same number of hours of operation. Scuffed blades damaged so that the material rubbed from the blade tip is less than 0.030 inch deep or less than half of the length of blade tip should not be replaced. Stone all feathered edges from the blades, stone any metal pickup from the exhaust shroud, or install a new exhaust unit. The minimum turbine blade-shroud clearance must not be less than 0.065 inch with a new cone nor less than 0.045 inch with the old cone.

2-140. MAINTENANCE.

a. Blend any nick or dent in the leading edge that is less than 0.015 inch deep. The blend must not exceed 0.015 inch deep.

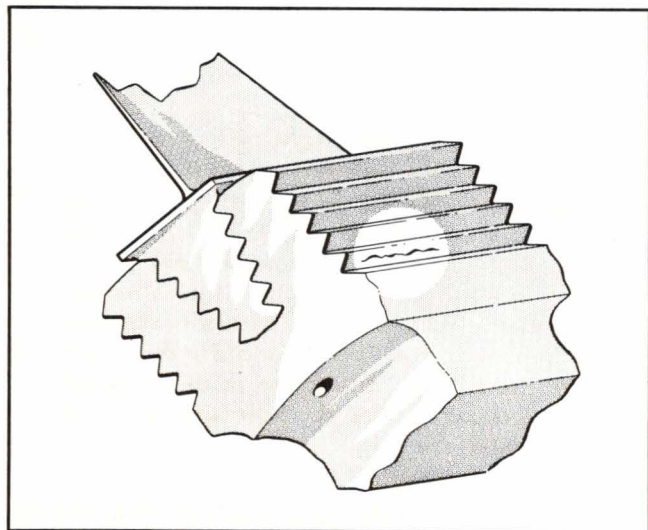


Figure 2-32. Turbine Wheel Serration Crack Location

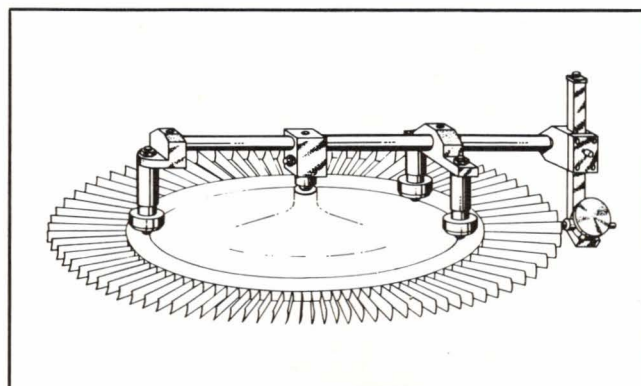
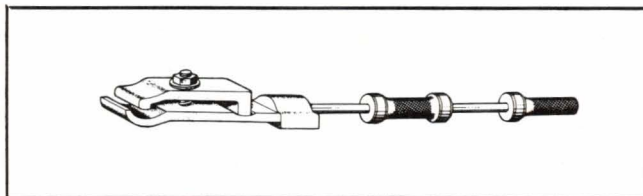


Figure 2-33. Turbine Blade Radial Stretch Gage No. 3682



56297

Figure 2-34. Turbine Blade Impact Puller No. 3143

b. Blend any nick or dent in the contour that is less than 0.015 inch deep. Smooth dents do not require blending. The blend must not exceed 0.015 inch deep.

c. After reworking, inspect the blades for cracks using the best of these methods that is available: fluorescent penetrant, dye penetrant, or 5-power magnifying glass.

2-141. Visually inspect GMR-235 blades (Allison part number 6724335). Replace all blades that have nicks, dents, or cracks beyond limits. Repair damaged blades according to the limits in paragraph 2-140.

2-142. TURBINE BLADE REMOVAL.

(Tool Group No. 11.)

a. Remove the shroud. (Refer to paragraph 2-154.)

b. Insert a piece of stencil paper between the rear face of the gas baffle and the forward side of the blade to be removed. Cover the aft side of the wheel with an aluminum shield to protect it from damage during blade removal.

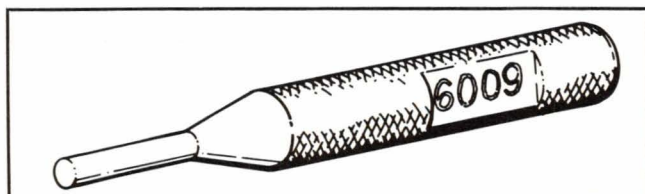
c. Use a one-pound ball peen hammer and a composition or plastic drift to drive the blade forward to shear the pin. Forward movement of approximately $\frac{3}{32}$ inch is enough to shear the blade locking pin. Control the forward movement of the blade by using light taps of the hammer to avoid damaging the gas baffle.

CAUTION

Do not use a metal drift. Do not attempt to shear the blade locking pin with the puller.

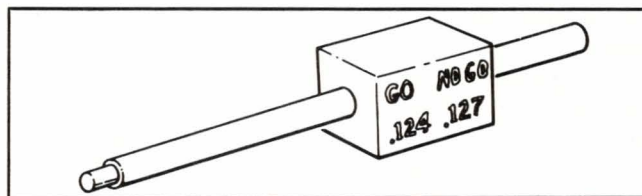
d. After shearing the blade pin, use the puller to withdraw the blade from the serrated slot of the turbine wheel. (See figure 2-34.)

e. Rotate the turbine wheel in the direction of rotation and inspect the gas baffle through the vacant wheel broach in the turbine wheel to be sure that the gas baffle is not damaged. Inspect for cracks in the blade slot. (Refer to paragraph 2-137.)



82593

Figure 2-35. Turbine Blade Pin Drift No. 6009



82593

Figure 2-36. Turbine Blade Pin Hole Gauge No. 3654, 3655, 3656, 3657, 3670, and 3671

f. Drive the sheared pin from the wheel with a drift with a one inch long straight shank of 0.112 inch diameter or with the special drift tool. (See figure 2-35.) Drive the pin from the fillet of the wheel toward the serrations.

Note

If the pin sticks in the pin hole, apply a small quantity of penetrating oil (Navy specification 0-2-B or refer to paragraph 2-30) and let it stand for two hours. Do not attempt to free sticking pins by heat application.

g. Remove the turbine blade 180° from the removed blade even if it is not damaged. Remove its locking pin. Remove only one pair of blades at a time and make certain they are diametrically opposite.

2-143. TURBINE BLADE INSTALLATION.

(Tool Group No. 10.)

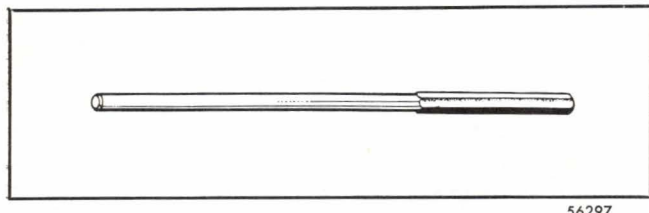
2-144. Gauge the locking pin holes with plug gauges to determine whether a standard or oversize locking pin will be required. (See figure 2-36.)

a. Insert the standard-size plug gauge in the serration end of the pin hole. If the hole is not damaged, and the *No-go* end of the gauge will not slip into the hole, use a standard-size pin. If the *No-go* end of the standard-size gauge will fit into the hole, try successively larger gauges until a gauge is found which will enter the hole on the *Go* end but will not enter the hole on the *No-go* end.

CAUTION

If the *Go* end of the gauge will enter the pin hole at the serration end but binds at the wheel-fillet end of the hole, do not try to force the gauge through the wheel fillet end of the hole. Select a tapered reamer of the same maximum diameter as the *Go* end of the gauge. (See figure 2-37. Insert the reamer through the serration end of the hole and ream the fillet end of the hole.

b. If the pin hole is damaged, gauge the hole to determine its maximum diameter. Select a tapered reamer of the proper size and ream the hole to the next oversize pin diameter.



56297

Figure 2-37. Turbine Blade Pin Hole Reamer No. 3273, 3274, 3275, 3672, and 3673

2-145. Before installing blades and locking pins, check the axial location of the blade in the wheel broach. Make this check before pinning blades to avoid shearing a new pin and reprocessing the pin hole when a blade fails to meet the axial position limits. Use the pin hole gauges for this check.

a. Insert the proper size gauge in the pin hole with the blade in position, and make sure the step end of the gauge enters and bottoms in the pin slot of the turbine blade. Determine this by feel. Do not hammer the gauge into position.

b. Measure the axial location of the rear end of the serrated base of the blade with relation to the rear face of the turbine wheel flange. This measurement must be plus 0.025, minus 0.010 inch. Use the special gauge. (See figure 2-38.)

c. If the rear face of the turbine blade base does not position within the $+0.025 - 0.010$ inch limits, switch the matched pair of blades to see if the mated blade will fall within the limits. If not, install another pair of mated blades which will position within these limits.

d. When the mated pair of blades has been positioned within the axial limits, remove the gauges from the pin holes and check the circumferential shake of the newly-installed blades. The shake must be 0.020-0.080 inch, measured at the blade tip.

e. Choose the proper size blade locking pins. The blade pins are color coded:

Size	Color
Standard	Natural
0.010 inch oversize	Blue
0.020 inch oversize	Green
0.030 inch oversize	Orange
0.040 inch oversize	Black
0.050 inch oversize	Purple

2-146. After the pin hole at the replacement blade locations is ready for installation of the pin, the axial location has been determined to be satisfactory using the proper gauge, and all burrs have been stoned from the vacant wheel serrations, install the mated pair of replacement blades in diametrically opposite locations.

Note

Install the heavier blade of the pair in the same location as the heavier removed blade.

2-147. INSTALLING SOLID LOCKING PINS.

a. Install a locking pin of the proper size in the lockpin hole with the elongated swaged section of the pin in line with the direction of rotation. Be sure that the end of the pin will enter the slot in the blade base.

b. Using a drift with a 0.112-inch diameter straight shank one inch long or the special drift, carefully tap the pin through the wheel hole into the blade slot until the blade begins to tighten in the wheel. (See figure 2-35.) The pin will be in its proper position with the inner end barely bottomed in the blade slot and the outer end completely entered into the wheel hole. The pin should not be tapped again.

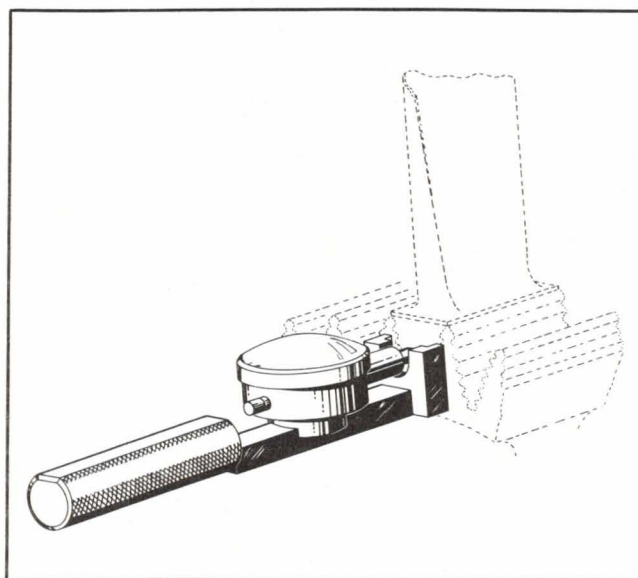
CAUTION

The locking pin will bend forward during installation if it is tapped after it has bottomed in the blade slot. This bending will cause the blade to move forward so that the $+0.025 - 0.010$ inch axial blade position limit with the rear face of the wheel cannot be met.

c. Tap each replaced blade on the platform at the rear of the blade base with a plastic or fiber drift to make sure that the blade is not binding on the pin and that it is free for circumferential shake.

2-148. The leading and trailing edge of the replacement blades when installed may be different from the other blades in the turbine wheel. Disregard this difference because the replacement turbine blades may have been mixed with other pinned blades.

2-149. The diameter across the replaced blade tips must be 26.400-26.434 inches.



82698

Figure 2-38. Turbine Blade Axial Location Gage No. 6010

2-150. After the exhaust cone shroud has been reinstalled, measure the blade tip-to-shroud clearance of each replaced blade to be sure that it is at least 0.045 inch.

2-151. **INSTALLING EXPANSION LOCKING PINS.** Use the solid-pin procedure with these exceptions:

- a. Gauge the pin holes and temporarily mark oversize holes.
- b. Place pins in the holes with the pin slot in the direction of rotation.
- c. Tap the pin for an oversize hole into a 0.124-0.126 inch diameter hole $\frac{1}{4}$ inch deep in a steel block.
- d. Drive a thin-wedged tool into the pin slot. Spread the pin so that the diameter measured 90° from the slot is 0.008-0.012 inch larger than the oversize hole diameter.
- e. Pin matched pairs of blades with the same type pin.
- f. If the pin hole is larger than 0.030 inch oversize, use a solid locking pin. Replace the pin in the opposite blade with a solid pin.

2-152. TURBINE SHROUD.

2-153. The turbine shroud rings the turbine blade tips. The shroud is bolted to the ring and tube.

2-154. **REMOVAL.**

- a. Remove the exhaust cone and flange reinforcing ring. (Refer to paragraph 2-160.)
- b. Remove the four recessed-head screws and locknuts which secure the shroud to the ring and tube rear flange. Remove the shroud.

2-155. **MAINTENANCE.** Replacing a turbine shroud may make the clearance less than the minimum limit

because some shrouds were machined from old single-piece exhaust cones and the flange thickness may be less than the standard shroud flange thickness. Do not replace engines for this reason unless relocation of the installed unit or a replacement unit will not correct the difficulty.

2-156. **INSPECTION.** (Tool Group No. 14.) Use the special gauge to measure the radial clearance between blade tips and the turbine shroud. (See figure 2-39.) It must not be less than 0.045 inch. Relocate the turbine shroud or replace it with another one if the measured clearance is not at least 0.045 inch. The replacement shroud must have a blade-to-turbine shroud minimum clearance of 0.065 inch. This is the requirement for a new or overhauled engine.

2-157. **INSTALLATION.**

- a. Position the shroud in the rear flange of the ring and tube and secure it with recessed-head screws and the special locknuts. Place the screws in the recess of the counterbores.
- b. Tighten the nuts to the specified torque.
- c. Check the shroud-to-turbine blade tip radial clearance and turbine wheel-to-inner exhaust cone axial clearance. (Refer to paragraphs 2-151 and 2-161.)
- d. After the clearance has been checked, install the flange reinforcing ring and the exhaust cone. (Refer to paragraph 2-164.)
- e. Recheck the torque for the four shroud retaining screws.

2-158. EXHAUST.

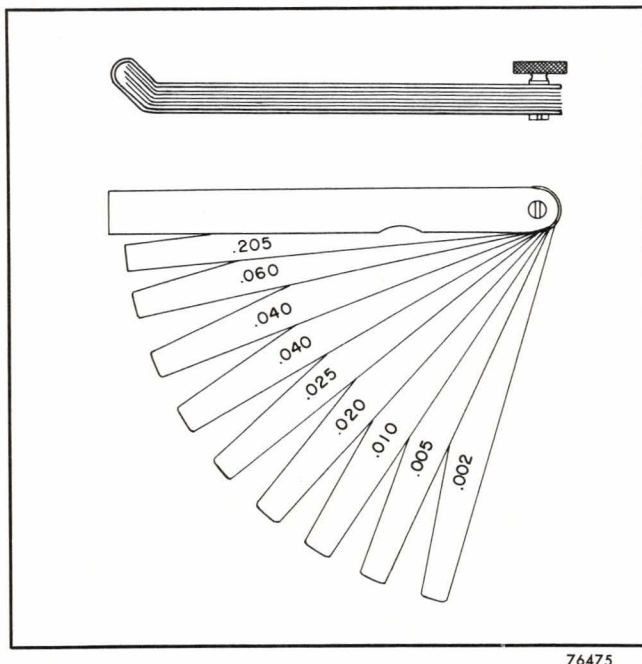
2-159. The exhaust consists of outer and inner cones. The front flange of the outer cone is bolted to ring and tube, and the rear flange is secured to the aircraft tailpipe. The inner cone, located closely behind the turbine wheel, is supported by four braces welded to the outer cone. (See figure 2-29.)

2-160. **REMOVAL.**

- a. Remove the exhaust cone thermocouples on J33-A-10A engines.
- b. Remove the wire lacing of the ring and tube rear flange insulation pad and carefully unwrap the insulation from the engine.
- c. Remove the wire lacing of the exhaust cone insulation pad and carefully unwrap the insulation pad from the engine.
- d. Carefully remove all bolts and nuts; remove the exhaust cone and flange reinforcing ring.

2-161. **INSPECTION.** (Tool Group No. 14.)

2-162. Use the special gauge to measure the exhaust cone axial clearance between the turbine wheel and inner exhaust cone. It should be 0.390-0.125 inch. (See figure 2-39.) If the measured clearance is over the maximum limit, replace it with a serviceable exhaust cone. If the measured clearance is less than the minimum limit, machine or hand-grind to remove material from the forward edge of the inner cone until the minimum clear-



76475

Figure 2-39. Turbine Wheel Radial Clearance Gauge No. 2825

ance of 0.125 inch is obtained. If more than 0.0625 inch of material is removed in order to obtain the 0.125 inch clearance, replace the exhaust unit or the turbine shroud or both. Measure the amount of radial misalignment between the top edge of the turbine blade platform and the inner cone outside diameter. If this misalignment is more than 1/8 inch, replace the exhaust unit.

2-163. Use the following procedure to inspect the exhaust unit:

- a. Insert a light through the hole in the center of the exhaust unit plate into the inside of the inner cone. Direct the beam of light toward the inside of the inner cone-to-inner cone flange weld area.
- b. Move the light along the weld area and examine the flange from the outside at the gap between the inner cone and the flange. Any light appearing through this gap indicates a crack in the flange.
- c. Replace any exhaust unit having cracks which have not been previously tack-welded by other activities.
- d. Replace the unit if the outer cone is distorted over 3/4 inch.
- e. Replace the shroud ring if it is damaged.
- f. Replace the unit if cracks adjacent to strut attaching welds are longer than 1/2 inch.
- g. Cracks 1 inch long are permitted in the strut walls.
- h. Cracks in the attaching flange bolt holes that extend toward the outer edge are permitted if no more than half the holes have cracks. Replace the unit if the cracks extend from the mounting flange bolt holes inward.

2-164. INSTALLATION.

- a. Install the flange reinforcing ring and the exhaust cone on the engine. The inner cone supporting vanes should be in the vertical and horizontal planes of the cone axis. Looking at the engine from the rear, make certain the thermocouple boss which is equidistant between two vanes is at the 10:30 o'clock position.
- b. Secure the cone with one or two bolts and nuts inserted from the front side of the flange. Bolts should be lubricated with the compound specified in paragraph 2-30.
- c. Position the four equally-spaced through bolts and make a preliminary measurement of the inner cone-to-wheel clearance. Refer to paragraph 2-162 for clearance limits. When clearance is within limits, tighten the remaining bolts and nuts evenly. Then loosen one nut at a time and retighten finger-tight. Tighten to final tension. Make a final check of inner cone-to-wheel clearance.
- d. Install the ring and tube rear flange insulation pad and lace securely.
- e. Install the exhaust cone insulation pad and lace securely.
- f. Install exhaust cone thermocouples on J33-A-10A engines. (Refer to paragraph 2-280.)

2-165. TORQUE LIMITS.

Size	Name	Location	Torque
3/8-24	Boots locknuts	Exhaust cone mounting	240-325 lb in.
3/8-24	Klincher locknuts	Exhaust cone mounting	225-250 lb in.

2-166. INSULATION PADS.

2-167. Two insulation pads cover the engine aft section. One is wired to the ring and tube and the other is around the exhaust cone.

2-168. REMOVAL. (Refer to paragraph 2-160.)

2-169. MAINTENANCE OF ENGINE SYSTEMS.

(See figures 2-40, 2-41, 2-42, 2-45, 2-48, and 2-49.)

2-170. FUEL SYSTEM ACCESSORY COMPONENTS.

2-171. The components of the fuel system are the dual pump, main fuel control, filter, starting control, nozzles, and drain valve. (See figures 2-41 and 2-42.)

2-172. EXTREME WEATHER MAINTENANCE. When the temperature is below -18°C (0°F), use MIL-F-5572 (grade 100/130) fuel for starting.

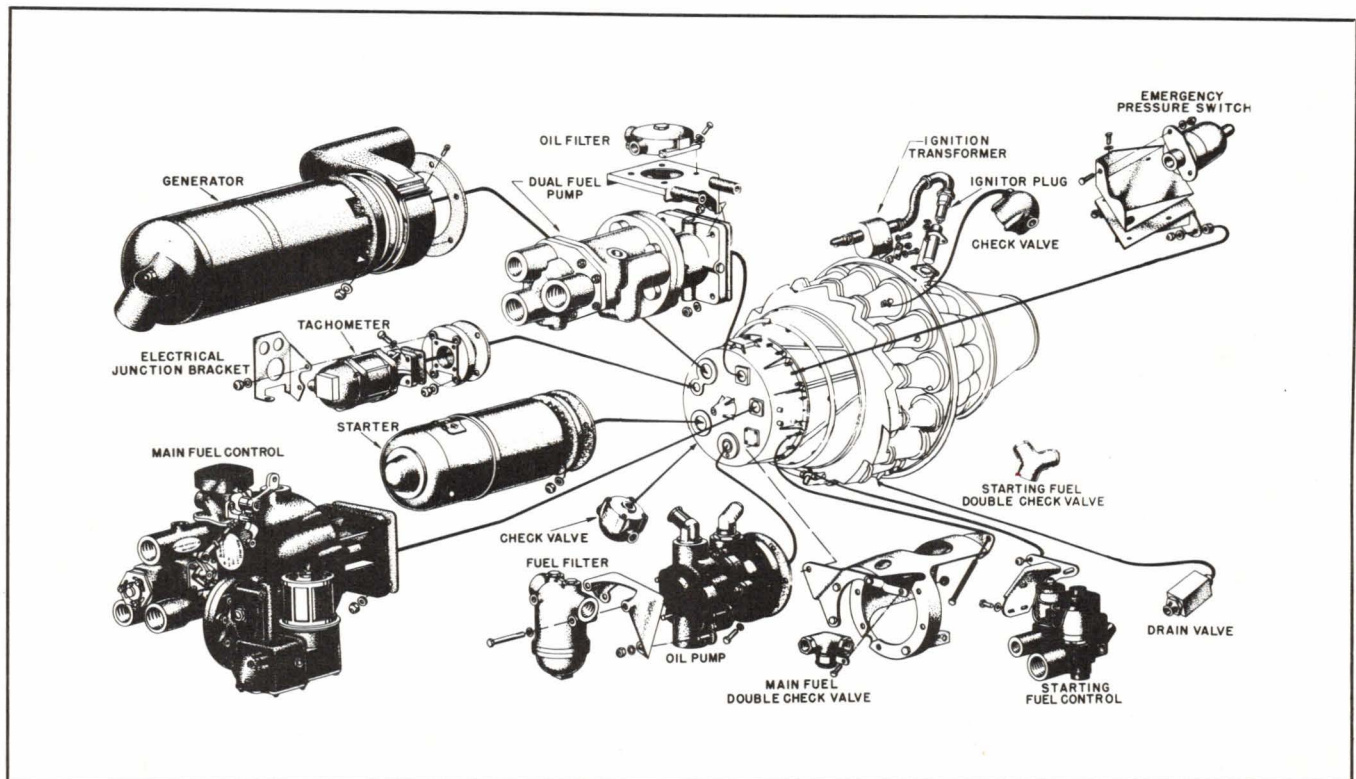
2-173. DUAL FUEL PUMP.

2-174. The engine-driven fuel pump has a main and an emergency element, both driven by a common shaft. The shaft has shear points to permit operation should one element fail.

2-175. REMOVAL.

- a. Disconnect both outlet hose at the filter.
- b. Disconnect the main control bypass hose at the pump fuel inlet fitting.
- c. If the engine is installed in the aircraft, disconnect all aircraft-furnished lines at the inlet fitting.
- d. Disconnect the drain hose at the bottom of the fuel pump mounting flange.
- e. Disconnect the quick-disconnect electrical lead from the fuel pump.
- f. Disconnect the hose to the filter at the oil pump.
- g. Disconnect the hose to the oil filter at the casing.
- h. Remove the two bolts which secure the emergency fuel filter to the oil filter mounting bracket. Remove the two nuts securing the filter bracket to the two top fuel pump mounting studs. Lift the bracket off the studs.
- i. Remove the two nuts from the lower fuel pump mounting studs. Lift the electrical bracket off its mounting stud and remove the fuel pump from the engine.

2-176. INSPECTION. (Tool Group No. 1.) Remove the dual fuel pump from the engine, brush the external splines of the driven shaft with a solvent, and inspect the internal splines of the pump drive shaft on the engine and the external splines of the driven shaft on the pump with this procedure:



61906M

Figure 2-40. Engine Accessories Location

a. Place a 0.010-inch feeler gauge against the worn flank of the external spline on the pump. If the wear land is greater than 0.010 inch, install a replacement pump with serviceable splines.

b. Remove the felt plug from the drive shaft and clean it with a solvent.

c. Clean the inside of the driveshaft with a brush and solvent.

d. Use the special tool to gauge the internal splines for wear. (See figure 2-43.) If the tool enters the shaft so that there is $\frac{1}{8}$ inch between the back edge of the tool splines and the front of the shaft, replace the engine.

e. Soak the felt plug in Ab-lube and replace it.

2-177. INSTALLATION. Whenever the fuel pump is removed, make the inspection in paragraph 2-176 before installing it.

a. Check the starting torque of the dual fuel pump before installation on the engine. The maximum allowable torque necessary to rotate the pump is 50 pound inches.

b. Coat the internal splines on the engine and the external splines on the pump with Ab-lube.

c. Mount the pump and gasket on the engine. Place the electrical lead bracket on the lower left stud and install the nuts on the two lower studs finger-tight.

d. Place the oil filter bracket and the oil filter and attached lines in position on the two top pump mounting studs. Install the nuts on the top studs and tighten the securing nuts.

e. Complete installation in reverse of removal.

2-178. FUEL FILTER.

2-179. The fuel filter is a replaceable-element, single-unit filter.

2-180. REMOVAL.

a. Disconnect each hose at the filter.

b. Remove the bolts which secure the filter to the bracket.

c. Remove the filter.

2-181. DISASSEMBLY. (See figure 2-44.)

a. Remove the filter sump and ring seal packing.

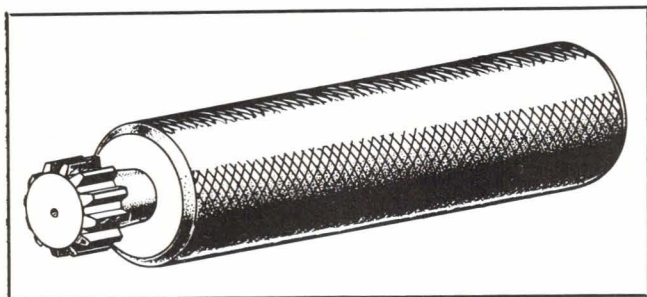
b. Unscrew the complete filter stack from the head, using an Allen wrench; remove ring seal packing.

Note

Inspect the filter stack for damaged filter packs. Do not disassemble further unless the packs are damaged.

c. Bend down the locking tabs of the washer. Remove the tube nut from the tube.

d. Remove the washer, retainer cup, packing ring, filter packs, and spacers from the tube. Do not remove the relief valve.



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Figure 2-43. Fuel Pump Spline Wear Gage No. 3696

2-182. CLEANING.

Note

Keep foreign material out of the inner passages during cleaning.

- Remove the filter stack as one unit from the filter head.
- Cap the opening in the end of the tube.
- Slosh the filter stack in an approved solvent.

CAUTION

Do not use compressed air for cleaning or drying the filter stack because there is danger of damaging the filter discs.

- Wash the inside surfaces of the filter head with an approved solvent.

- Remove the cap.

Note

Ultrasonic cleaning is recommended if the equipment is available.

2-183. ASSEMBLY.

- Assemble the filter stack by installing alternately a filter pack and a spacer on the tube until the twelve packs and eleven spacers are in place. Install the retainer cup last.
- Install the washer and tube nut. Tighten the nut to the specified torque and safety by bending up a tab of the washer.
- With the ring seal between the filter head and the filter stack, tighten the stack to the specified torque.

CAUTION

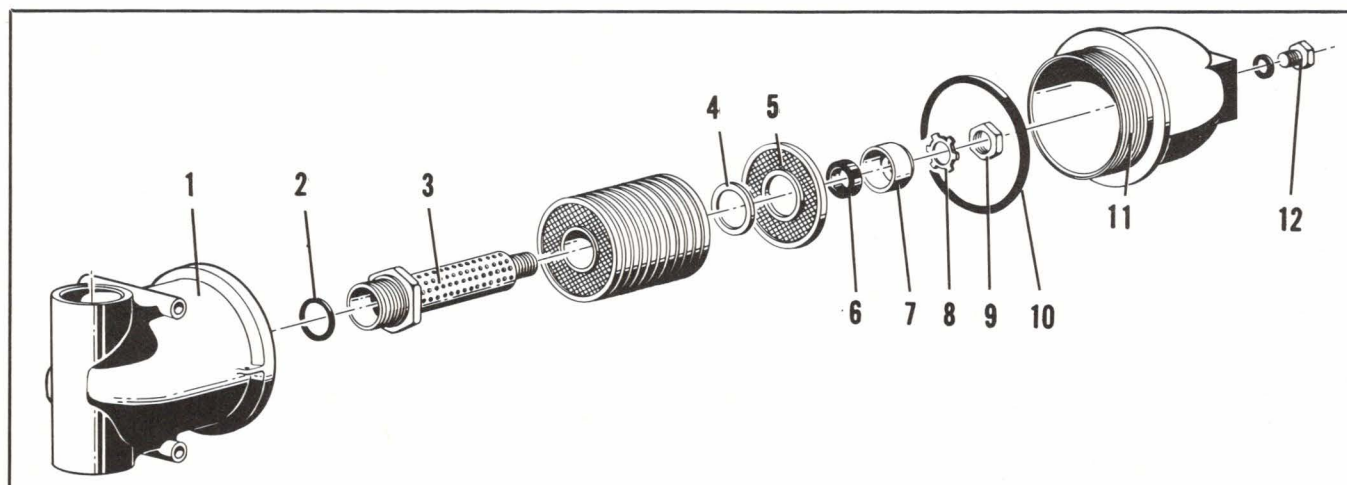
Do not install the filter stack by tightening the tube nut.

- Install the ring seal and the filter sump on the head with the specified torque. Apply AN-C-128 to the threads of the filter sump.

2-184. INSTALLATION. Install in reverse of removal.

2-185. TORQUE LIMITS.

Name and Location	Torque
Filter tube nut on filter stack.....	60-80 lb in.
Filter stack in head.....	100-110 lb in.
Filter sump on head.....	35-40 lb ft



76298

- Filter Head
- Ring Seal
- Tube

- Spacer
- Filter Disc
- Packing Ring

- Retainer Cup
- Lockwasher
- Tube Nut

- Ring Seal
- Filter Sump
- Plug

Figure 2-44. Fuel Filter Details

2-186. STARTING FUEL CONTROL.

2-187: The operation of the starting fuel control is based upon a timed progressive increase of fuel flow to the engine which permits safe acceleration of engine speed from initial light-up. The throttle-operated fuel system cutout switch opens the fuel inlet valve during starting to allow fuel to flow to the starting control; this switch also closes the drip valve in the starting fuel control. Initial fuel is discharged into the No. 7 and 14 combustion chambers where ignition occurs; then a slug of fuel is discharged into the remaining combustion chambers to permit the spread of the fire from No. 7 and 14 combustion chambers to the remaining chambers. The supply of fuel is progressively increased at a rate to give maximum safe acceleration of engine speed to the speed required for transfer to the main fuel control. When the throttle is moved to *IDLE*, the switch closes the inlet valve and the main fuel control governs flow.

2-188. REMOVAL.

- a. Prepare the unit for storage in accordance with instructions in Section IV.
- b. Remove the screws on each side of the terminal cover and lift off the cover. Detach the electrical lead and replace the cover.
- c. Disconnect the aircraft-furnished drip valve hose.
- d. Disconnect the two check valve lead hose at the control.
- e. Disconnect the main double check valve-to-starting control hose at the control.
- f. Disconnect the starting double check valve-to-starting control hose at the control.
- g. Disconnect the fuel manifold coupling nuts at the starting fuel control outlet tee.
- h. Remove the nuts securing the control bracket to the diffuser studs. Remove control from the engine.
- i. Remove the three fillister head screws securing the bracket to the control.

2-189. INSTALLATION.

- a. Prepare the starting fuel control for service as outlined in Section IV.
- b. Install in reverse of removal.

2-190. **ADJUSTMENT.** Use this procedure to avoid overtemperature starts at fields over 4000 feet elevation.

- a. Check the auxiliary power unit to make sure that the engine can be cranked to 10% speed (1175 rpm).
- b. Check the series relay in the starter relay panel to make sure it does not allow the starter to drop out below 15% speed (1760 rpm).
- c. If the engine still starts hot, break the seal, loosen the jam nut, and turn the regulator valve adjusting screw counterclockwise to obtain 30-32% stabilized idle speed (3525-3660 rpm). If the engine is transferred to a lower elevation readjust the starting control.

2-191. TESTING.

- a. When testing the starting fuel control drip valve, place the ignition switch *OFF* if the aircraft is so equipped, or disconnect the ignition unit-to-main disconnect plug lead at the ignition system connector.

- b. Energize the drip valve by moving the starting fuel switch to *START*.

- c. Energize the aircraft boost pump and momentarily open and then immediately close the throttle.

- d. Draining from the drip valve should occur.

- e. Re-install the ignition unit-to-main disconnect plug lead at the ignition system connector.

2-192. TORQUE LIMITS.

Size	Name	Location	Torque
3/4-16	Bushing	Starting fuel control inlet	150-200 lb in.

2-193. MAIN FUEL CONTROL.

2-194. The main fuel control prevents the engine from overspeeding beyond a maximum governed speed; it preserves speed regardless of changes in ambient pressure; it limits the engine acceleration rate to prevent excessive exhaust gas temperature; and it limits the engine deceleration rate to prevent flameout.

2-195. REMOVAL.

- a. Prepare the unit for storage as outlined in Section IV.
- b. If the engine is installed in an aircraft, remove any aircraft-furnished hose which may interfere with removing the main control.
- c. Disconnect the main control bypass-to-fuel inlet fitting hose at the control.
- d. Disconnect the filter-to-control hose.
- e. Disconnect the main control-to-main and starting double check valve hose at the control.
- f. If the engine is installed, disconnect aircraft-furnished drain lines.
- g. Disconnect the control-to-pressure switch hose at the control.
- h. On early-model controls, remove the four recessed-head screws securing the cover on the main control throttle switch housing. Remove the cover and lift the switch off its mounting dowels. Loosen the screws and disconnect the electrical leads from the switch. Re-install screws, switch, and cover. On late-model main fuel controls, remove the waxed linen threads from around the lead wires, slide the tubes back from connections, and disconnect the control short leads from the harness leads.
- i. Remove the nuts securing the control to the top mounting studs. Remove the electrical lead brackets from the stud.
- j. Remove the nuts securing the control to the lower studs. Lift the control from the engine.

2-196. INSTALLATION.

- a. Prepare for service as outlined in Section IV.
- b. Install the main control and gasket on the mounting studs. Install the nuts on the two lower mounting studs finger-tight.
- c. Connect the throttle switch leads in reverse of removal. Wrap at least three turns of waxed linen thread around both ends of each set of tubes and tie securely.
- d. Place the electrical lead supporting bracket on the upper right mounting stud. Install the nuts and tighten all the mounting nuts to the specified torque.

TABLE VI

Fuel Pressure Switch Setting Limits

	<i>Make</i>	<i>Break</i>
J33-A-10A	60-70 psi	90-100 psi
J33-A-20	33-35 psi	33-37 psi

e. Finish installation in reverse of removal.

2-197. **ADJUSTMENT.** (Refer to paragraph 2-58.) An engine which has been properly adjusted for operation with MIL-F-5572 (grade 100/130) must have the full-throttle adjustment changed before servicing with MIL-F-5624 (grade JP-4.)

2-198. FUEL PRESSURE SWITCH.

2-199. Fuel pressure at the main control outlet is sensed by the fuel pressure switch. If the pressure drops below the switch setting, the switch senses failure of one element of the fuel pump and turns on the fuel pump warning light.

2-200. REMOVAL.

- At the switch disconnect the hose to the main control.
- Detach the electrical connector from the rear side of the switch.
- Disconnect the electrical ground lead at the switch bracket (J33-A-20).
- Remove the bolts and nuts which secure the pressure switch to the switch bracket.

2-201. **INSTALLATION.** Install in reverse of removal. Refer to table VI for the correct switch settings.

2-202. TESTING.

- With the engine operating, depress the pump check switch.
- The fuel pump warning light should come on.

2-203. FUEL MANIFOLD.

2-204. The fuel manifold carries fuel from the main or starting fuel control to the fuel nozzles. Spring-loaded minimum-pressure check valves are located in combustion chambers No. 7 and 14. During starting, when the fuel pressure in the starting fuel manifold is greater than that in the main fuel manifold, the valves permit fuel flow from the starting manifold only to combustion chambers No. 7 and 14. (See figure 2-14.)

2-205. REMOVAL.

- Disconnect all coupling nuts securing the manifold to the air adapter fittings, the No. 7 and No. 14 check valves, and the starting fuel control.
- Remove the hose at the manifold inlet fitting.
- Remove all clamps securing check valve hose to the manifold.
- Disconnect the starting check valve hose at the valves.

e. Disconnect the igniter plug harness leads at each transformer.

f. Disconnect the main oil tube and rear scavenge tube-to-accessory housing hose at the front truss ring. Remove the bolt and nut which secures the scavenge hose to the fuel manifold.

g. Remove the clamps securing the manifold to the engine.

h. Remove the manifold, being careful not to damage it.

2-206. **MAINTENANCE.** Cracked tube nuts may be replaced or flared tube ends repaired if the tubing is long enough to be reconnected after the flared end is cut off.

a. If the flared tube end is to be repaired, cut off and re-flare the tube end.

b. If nut is to be replaced, cut off the flared end. Replace the nut and sleeve; re-flare the tube end.

c. Bend the tube slightly in the U section to make up for its reduced length.

d. If the tubing is too short after the flared end is cut off, replace the manifold.

2-207. INSTALLATION.

- Install in reverse of removal.
- Re-route the check valve hose which leads to the No. 14 combustion chamber so that it will lie below the point of maximum diameter of the No. 13 air adapter rear flange.

2-208. FUEL NOZZLES.

2-209. The fuel nozzle is a single-line, duplex unit containing a valve. On starting, the fuel flows through a filter screen, bypasses the valve, and sprays into the combustion chamber. When the fuel pressure increases, the valve opens and more fuel passes through the valve and sprays into the combustion chambers. (See figure 2-16.)

2-210. **REMOVAL.** (Refer to paragraph 2-106.)

2-211. MAINTENANCE.

a. Remove all nozzles and check for tip damage or carbon deposits on the spray tips. Do not disassemble the nozzles.

b. If necessary to clean the spray tip, flow fuel through the nozzle at low pressure and use a soft cloth and standard test fluid to clean it. Use a special carbon solvent if necessary.

CAUTION

Use extreme care not to damage the mirror finish and edges of the spray tip.

c. Any damage to the nozzle spray tip is cause for replacement.

2-212. **INSTALLATION.** Coat the male threads and the shoulder of the fuel nozzle with MIL-L-3572. Coat a new fuel nozzle gasket with Permatex No. 2. Install in reverse of removal.

2-213. TORQUE LIMITS.

Size	Location
3/4-16	Fuel nozzle

Torque
80-90 lb ft

2-214. LUBRICATION SYSTEM ACCESSORY COMPONENTS.

2-215. The engine is lubricated by a wet-sump system which furnishes filtered oil under pressure to the accessories drive coupling, the turbine rotor coupling, and the bearings of the rotor shafts. The bearings in the accessory drive case are lubricated by a splash system. The supply reservoir is formed by the gear casing and the front compressor bearing support. The reservoir capacity is three gallons. The oil level may be determined with a bayonet gauge on the right side of the accessory gear casing.

2-216. The two-element gear pump has on its mounting flange a port through which oil from the casing reservoir enters a filter screen into the pressure element. The oil passes from the pump through a filter and six oil jets onto the rotor bearings and couplings. Oil seals prevent oil leaking past the front and rear compressor bearings and the rear turbine bearing.

2-217. Scavenge oil is returned to the reservoir by gravity and by pump suction. Oil from the front compressor bearing and the accessories drive coupling shaft drains

directly into the reservoir. Oil from the turbine coupling and the other three rotor shaft bearings drains into a sump from which the oil is pumped by the scavenge element through a filter screen into the reservoir. (See figure 2-45.)

2-218. MAINTENANCE. When excessive oil consumption is suspected, accomplish the following check to determine the exact oil consumption.

- Fill the oil reservoir to the 12-quart mark on the oil bayonet gauge.
- Drain the oil into a clean five-gallon container. Let the oil drain for five minutes.
- Weigh and record the weight of the container and oil. Put this oil back into the reservoir.
- Make a normal one-hour flight.
- Stop the engine and drain the oil into the five-gallon container. Let the oil drain for five minutes. Do not use this container for other purposes during this check. Do not clean it before the check is finished.
- Weigh and record the weight of the container and oil. The difference between the recorded weights should not exceed two pounds per hour for the check flight.
- Check oil seals and external oil lines for leaking. Check the aircraft wake for excessive smoking. Excessive oil leaking past the front compressor oil seal may be detected by the presence of smoke in the cockpit when the pressurization system is ON, or by a streamer of blue-white smoke from the tail pipe.

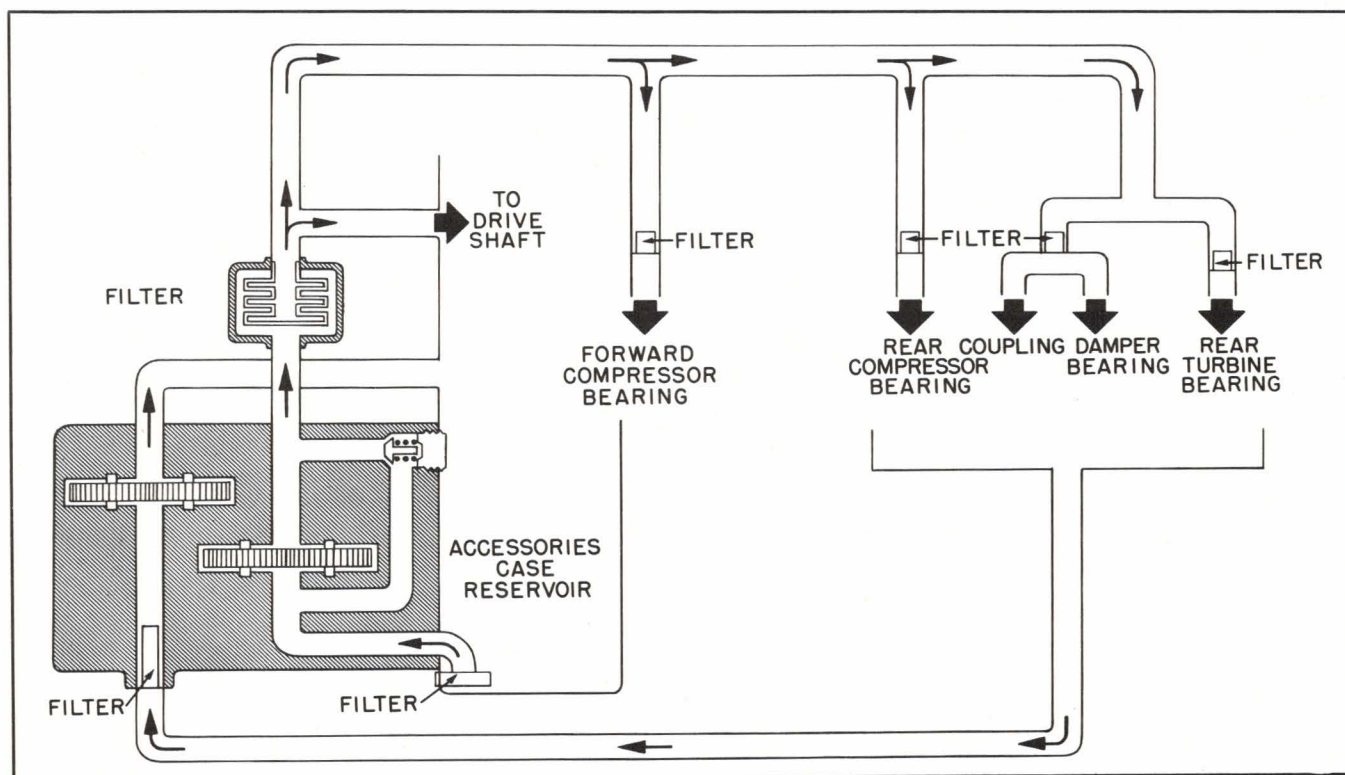
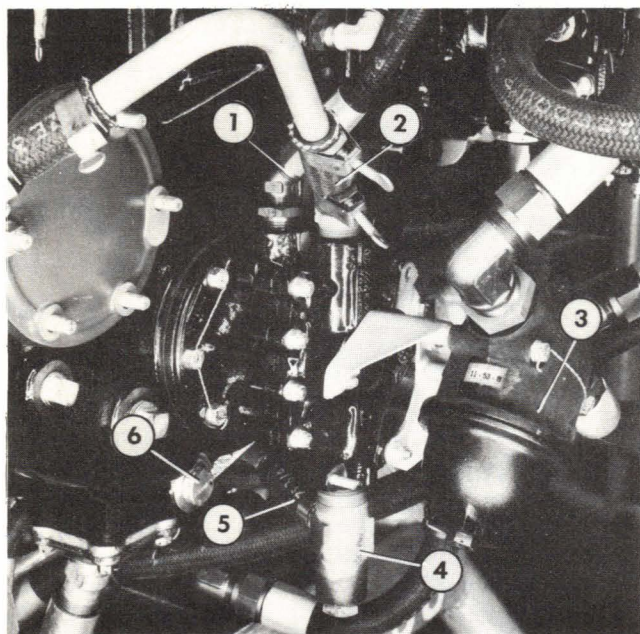


Figure 2-45. Oil System Schematic

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1. Oil Pump Outlet to Filter
2. Scavenge Outlet to Accessories Case
3. Fuel Filter
4. Scavenge Inlet Filter
5. Scavenge Inlet Hose
6. Pump Inlet Filter

Figure 2-46. Oil Pump

h. During ground operation oil may be drawn past the impeller shaft front oil slinger and the oil seal by a low-pressure area created at the hub of the impeller. This condition will not warrant engine removal and can be detected by oil leaking at the bottom of the front support truss ring. This leaking will stop when sufficient ram is obtained to create a positive air pressure in that area. Opening the engine access doors during ground run-up produces a more favorable pressure balance across the seal.

2-219. Use this procedure to install the oil dipstick:

- a. When oil gauge is inserted in filler cap adapter, turn the knurled ring of the cap counterclockwise. Be careful to insert the oil gauge in the cap adapter so that the gauge passes through the proper hole in the reinforcing web of the accessory case.
- b. To seal the oil cap, turn it clockwise only until the yellow marks line up.
- c. Pull out on the cap to check for locking.

2-220. **EXTREME WEATHER MAINTENANCE.** Use MIL-O-6081 oil (grade 1010) when the temperature is above 20°F. Use either grade 1010 or grade 1005 oil when the temperature is +20°- -20°F. Use grade 1005 when the temperature is below -20°F.

2-221. OIL PUMP.

2-222. The oil pump, mounted on the accessories drive casing, contains both pressure and scavenge gears. The shaft which drives the pressure gears also drives the scavenge gears. An internal passage contains a pressure relief valve which bypasses oil from the pressure outlet

TABLE VII

Oil Pressure Limits

	Engine Speed	Oil Pressure
At ambient temperature of 15°C (59°F) or above at any altitude	Over 75% (8800 rpm)	7-42 psi
At ambient temperature of less than 15°C (59°F) at any altitude following warm-up	Over 75% (8800 rpm)	7-50 psi
Minimum oil pressure at idle	34% (4000 rpm)	2 psi
Maximum oil pressure fluctuation		3 psi
Maximum oil pressure during warm-up		100 psi

port to the pump inlet. (See figure 2-46.) Oil pressure limits are shown in table VII.

2-223. REMOVAL.

- a. Loosen the hose clamps and push back the hose which connects to the gear casing inlet tube and the main scavenge tube to the oil pump.
- b. At the pump disconnect the hose to the filter.
- c. Remove the bolts securing the pump to the accessories gear case. Remove the pump.
- d. Inspect and clean the scavenge tube oil filter.

2-224. **INSTALLATION.** Install in reverse of removal.

2-225. OIL FILTER.

2-226. The oil filter has a cartridge stack element and an integral bypass valve which opens at a pre-set pressure differential. (See figure 2-42.)

2-227. REMOVAL.

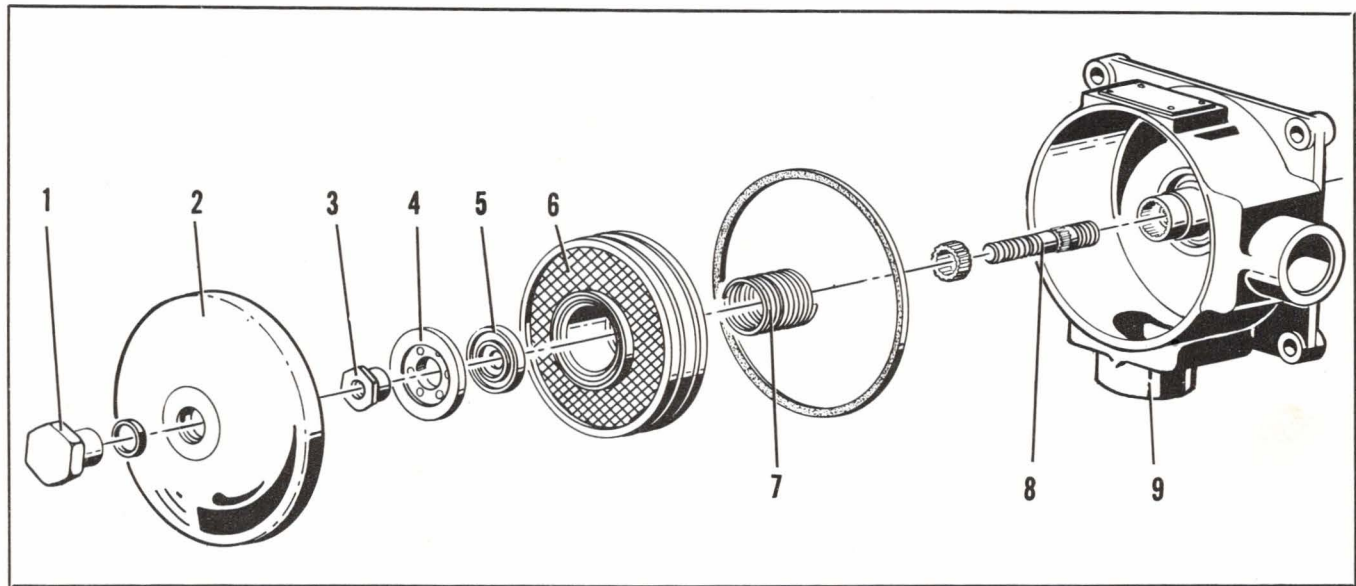
- a. Disconnect the oil pressure-sensing line at the aircraft connection.
- b. At the filter fitting, disconnect the hose to the casing.
- c. At the filter fitting, disconnect the hose to the front bearing support.
- d. At the filter disconnect the hose to the oil pump.
- e. Remove the bolt and spacer fastening the accessories housing vent tube clamp to the oil filter. Slide the clamp out of position. Remove the three remaining bolts. Lift off the filter.

2-228. **DISASSEMBLY.** (See figure 2-47.)

- a. Remove the seal nut, cover, and gasket from the filter body.
- b. Remove the sleeve nut.
- c. Lift the valve seat and valve from the filter body stud.
- d. Lift the cartridge and relief valve spring from the stud.

CAUTION

Do not disassemble the cartridge.



1. Seal Nut
2. Cover

3. Sleeve Nut
4. Valve Seat

5. Relief Valve
6. Filter Element

7. Spring
8. Stud

82697
9. Body

Figure 2-47. Oil Filter

2-229. CLEANING.

- a. Cap both ends of the cartridge shaft.

CAUTION

Take care to keep foreign material out of the inner passage of the filter cartridge.

- b. Flush the cartridge in an approved solvent.

CAUTION

Do not use anything else to dry or clean the body or the element of the filter.

- c. Remove the caps and inspect the filter discs.
- d. Flush the filter body in an approved solvent.

2-230. ASSEMBLY. Install the parts on the filter body stud in the following order: relief valve spring, cartridge, valve, valve seat, and sleeve nut.

2-231. INSTALLATION.

- a. Secure the filter with three bolts $2\frac{1}{32}$ inch long, one bolt $1\frac{9}{32}$ inches long, and four thin washers.
- b. Install in reverse of removal.
- c. Check for oil leaks on initial run-up or whenever the cover has been removed.

2-232. TORQUE LIMITS.

Size	Location	Torque
$\frac{5}{16}$ -24	Element sleeve nut	25-30 lb in.
$\frac{3}{16}$ -24	Seal nut	80-100 lb in.
$\frac{3}{4}$ -16	Mounting nut	200-250 lb in.

2-233. OIL SUMP-TO-PRESSURE PUMP AND TURBINE SUMP-TO-SCAVENGE PUMP FILTER SCREENS.

2-234. The oil sump-to-pressure pump filter screen is on the lower front side of the accessories case; it filters oil before it enters the pressure element of the oil pump. The turbine sump-to-scavenge pump filter screen is in the scavenge inlet of the oil pump; it filters oil returning from the turbine section of the engine before it enters the scavenge element of the pump.

2-235. REMOVAL.

2-236. Remove the oil sump-to-pressure pump filter screen and examine it. Arrange to catch the oil. Flush the screen with an approved solvent, catching any residue in a strainer with at least $\frac{1}{32}$ -inch mesh. If particles are found reject the engine.

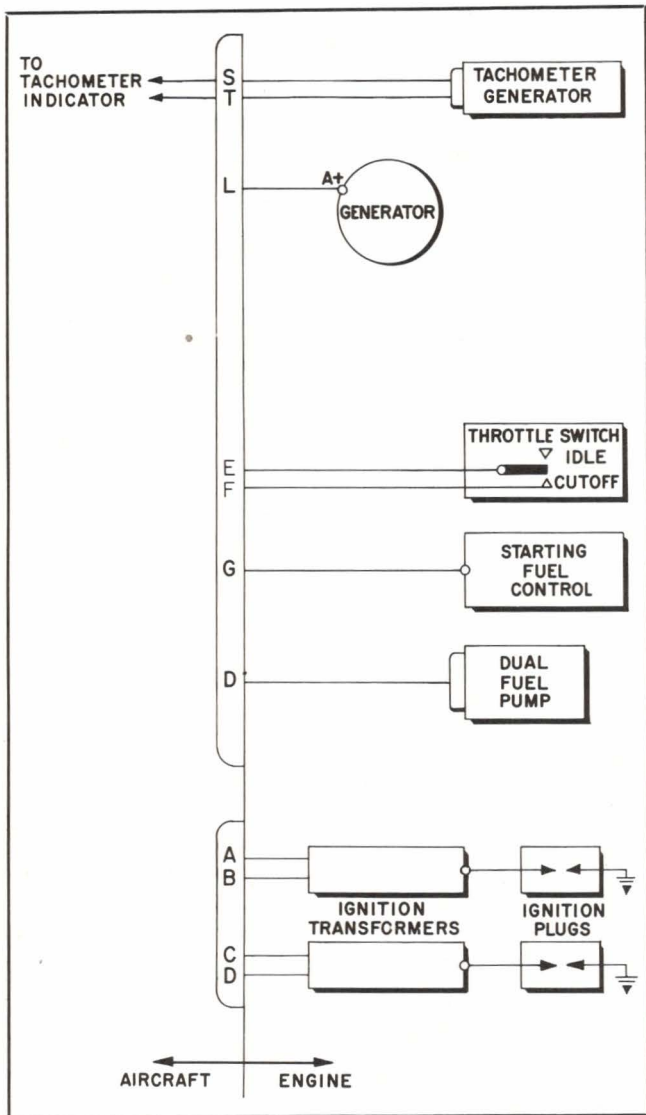
2-237. Remove the turbine sump-to-scavenge pump filter screen and examine it. Catch the oil in a container.

- a. Flush the screen with an approved solvent, catching any residue in a strainer with at least $\frac{1}{32}$ -inch mesh. If particles are found in this inspection, remove the turbine sump-to-accessories case sump scavenge oil hose. Flush the hose with an approved solvent, catching any residue in the strainer.

- b. If particles of metal are found reject the engine. If particles of neoprene are found and if there is no evidence of external leaking, continue the engine in service. If neoprene is discovered and the engine is leaking externally, reject the engine.

Note

If the engine oil is to be reused, prevent its contamination.



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Figure 2-48. J33-A-10A Electrical Wiring Diagram

2-238. INSTALLATION. Install in reverse of removal. Coat the threads of the scavenge screens with MIL-L-3572.

2-239. TORQUE LIMITS.

Size	Name	Location	Torque
3/4-16	Nut	Oil filter screen	200-250 lb in.

2-240. ELECTRICAL SYSTEM ACCESSORY COMPONENTS.

2-241. The electrical system accessory components are the starter, generator (J33-A-20), tachometer generator (J33-A-20), ignition transformers, igniter plugs, thermocouples (J33-A-10A), and thermocouple harness and leads (J33-A-10A). (See figures 2-48 and 2-49.) The ignition system is used only for engine starting.

2-242. TORQUE LIMITS.

Size	Name	Location	Torque
10-32	Self-locking nuts	Ignition cable clamps	20-25 lb in.

Electrical coupling nuts except igniter plug leads:

- Tighten as tight as possible with fingers.
- Tighten additional 30-40°.

2-243. STARTER.

2-244. The direct-cranking starter is located on the lower right side of the accessories drive case.

2-245. REMOVAL.

- Disconnect the starter electrical cables.
- Remove the six nuts securing the starter to the case. Lift off the starter and gasket.
- Remove the cotter pin, nut, and washer from the armature shaft.
- Remove the pinion gear and key.

2-246. MAINTENANCE.

- Starter brushes should have a free fit without excessive side play. Wipe binding brushes clean and brush boxes with a cloth moistened with unleaded gasoline. The surface of each brush should touch its commutator 100% in the direction of rotation and at least 75% parallel to the shaft.

CAUTION

Do not use fuel containing lead compounds because the lead will plate on the commutator and impair the starter efficiency. Carbon tetrachloride will cause corrosion.

- Replace worn brushes when they become shorter than 3/8 inch. Run in new brushes on the motor until at least a 75% seat is obtained. If this is not possible, seat the brush by inserting a strip of No. 0000 sandpaper between the brush and the commutator. With the sanded side next to the brushes, slowly pull the paper in the direction of rotation. Repeat this procedure until the brushes are at least 75% seated. Do not use coarse sandpaper or emery cloth. Remove all sand and metal particles in the starter with dry compressed air.

- Smooth and polish rough or dirty commutators with No. 0000 sandpaper.

CAUTION

Do not use coarse sandpaper or emery cloth. After polishing, clean the starter thoroughly to remove all sand and metal particles. If these particles are not removed, excessive wear of the brushes and commutator will result. Turn very rough or badly pitted commutators on a lathe or replace them.

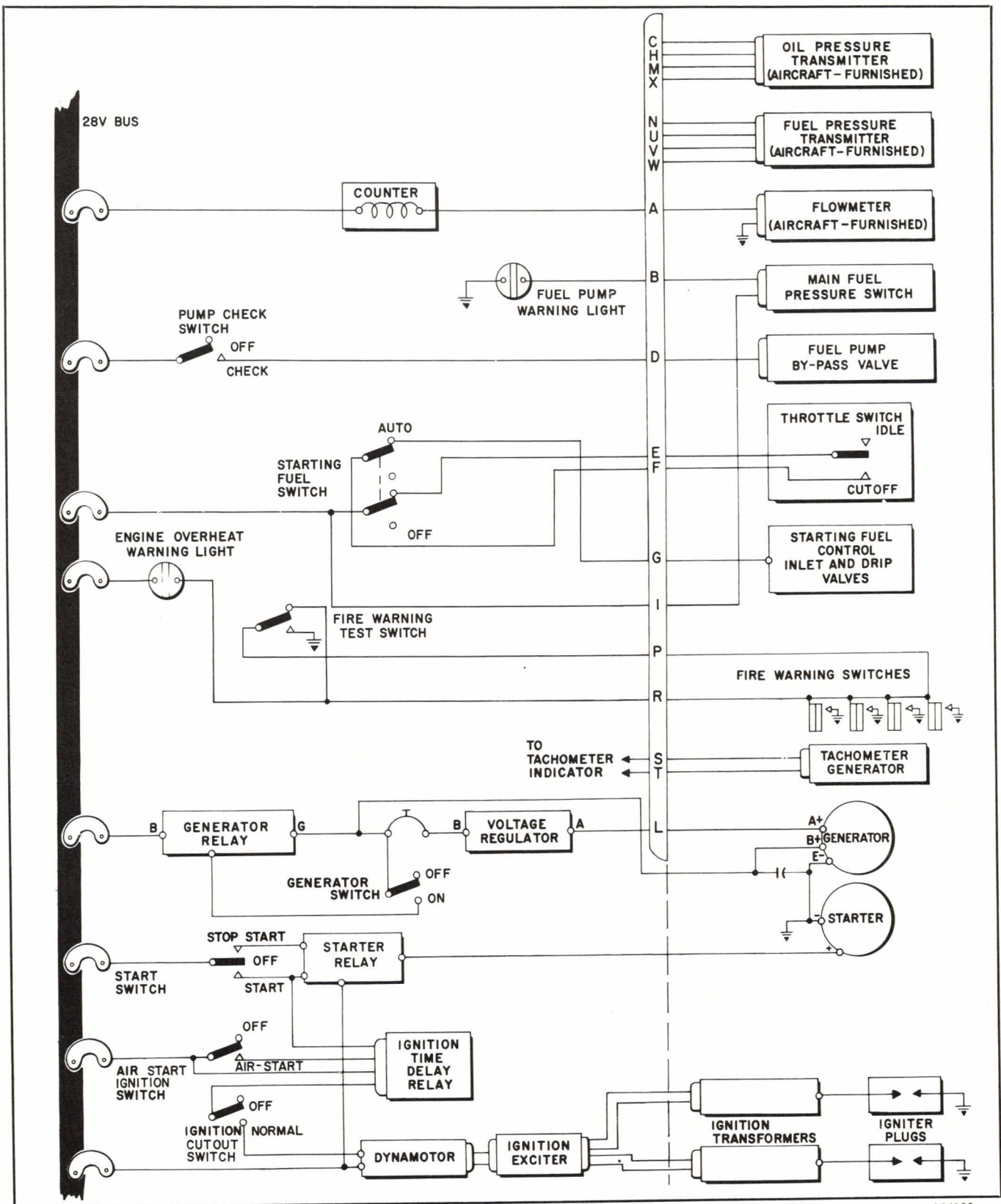
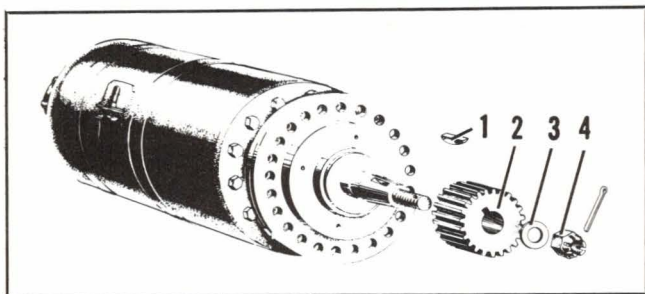


Figure 2-49. J33-A-20 Electrical Wiring Diagram



1. Key
2. Pinion Gear
3. Washer
4. Nut

Figure 2-50. Starter and Drive

2-247. INSTALLATION.

- Install the key in the armature shaft of the replacement unit. (See figure 2-50.)
- Install the gear on the armature shaft and secure with washer and castellated nut. Safety with a cotter pin.
- Install the gasket.
- Install the replacement starter so that the electrical terminals are in their proper position. Install washers and nuts.
- Reconnect the electrical cables.

2-248. ADJUSTMENT. Adjust the aircraft starter controls so that the starter drops out at 17-19% speed (2000-2230 rpm).

2-249. TESTING. Turn off all fuel and ignition switches and selector valves. With the starter control operating, install a test lamp across the starter terminals. Check the power supply. If the power supply is not satisfactory, replace the starter.

2-250. GENERATOR (J33-A-20).

2-251. The generator provides current for aircraft use.

2-252. REMOVAL.

- Loosen the two hose clamps securing the generator cooling air tube to the generator cooling air shroud. Push the hose back onto the rear tube.
- Remove the generator condenser and disconnect the generator electrical cables.
- Remove the nuts and washers holding the generator to the case. Lift off the generator and gasket.
- Remove the cooling shroud from the generator.

2-253. MAINTENANCE.

- The brushes should be inspected for even wear, freedom of movement in the brush holder, and length. Replace the brushes if they are chipped or cracked, if the leads are loose or frayed, or if they are worn near minimum length. Blow out accumulated carbon dust with dry compressed air.
- The commutator should be smooth and free from badly blackened or pitted bars. A slightly darkened appearance is normal under good operating conditions. If the commutator needs re-surfacing, replace it.

2-254. INSTALLATION.

- Install the cooling shroud on the replacement gen-

erator. Position the adapter ring on Jack and Heintz generators so that its cut-out will provide clearance for the tachometer generator.

- Coat the drive splines with the lubricant specified in paragraph 2-30.

- Install the gasket and generator on the gear case. Position the electric terminals of the generator on the right side of the engine 30° below the horizontal center line of the generator.

- Reconnect the electrical cables.

Note

Make sure that the generator A lead is tight enough to prevent vibration in the air inlet stream.

2-255. TACHOMETER GENERATOR (J33-A-20.)

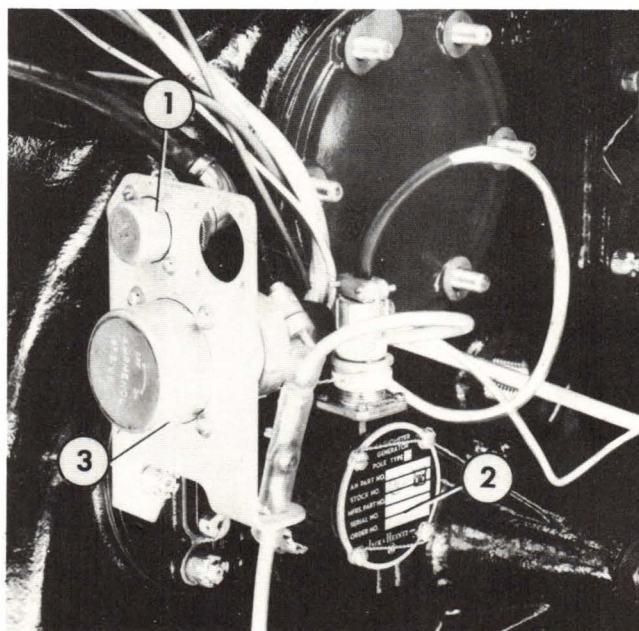
2-256. The tachometer generator is an a-c generator which is used with a cockpit indicator to show engine speed. The tachometer generator is mounted on the accessories case. (See figure 2-51.)

2-257. REMOVAL.

- Disconnect the electrical lead from the tachometer generator.
- Remove the bolts securing the unit to its adapter pad. Remove the tachometer generator.

2-258. INSTALLATION.

- Install the tachometer generator so that the electrical receptacle is properly located. Install the washers and bolts.



1. Ignition Connector
2. Tachometer Generator
3. Main Engine Connector

Figure 2-51. Tachometer Generator

b. Reconnect the electrical lead.

2-259. TORQUE LIMITS.

Size	Name	Location	Torque
1/4-28	Nuts	Tachometer generator mounting	35-45 lb in.

2-260. IGNITION TRANSFORMERS.

2-261. The two ignition transformers are mounted on the No. 7 and 14 diffuser-to-air adapter spacer split lines. They increase ignition impulse voltage to a potential necessary to bridge the igniter plug gaps. (See figure 2-14.)

2-262. REMOVAL.

a. Turn the aircraft igniter switch *OFF* if the aircraft is so equipped. Disconnect the high-tension shielded lead and the ignition harness lead at the transformer.

CAUTION

Serious personal injury will result from contact with an energized transformer.

b. Remove the input lead. If the output lead is less than 12 inches long, remove it at the igniter plug before disconnecting it at the transformer.

c. Remove the bolts securing the transformer to the engine and remove the unit. It is not necessary to remove the transformer mounting bracket from the engine on later models.

2-263. MAINTENANCE. If operating difficulties or tests indicate that a transformer is defective, replace the spark gap before rejecting the complete transformer.

a. Remove lockwire from the hexagonal plug. (See figure 2-52.)

b. Remove the plug, copper washer, and compression spring.

c. Remove the spacer washer from the recess in the transformer. Remove the sealed gap. Use dividers inside calipers or the jaws of thin-nosed pliers to remove the washer and gap. (See figure 2-52.)

CAUTION

Use light pressure when removing the spark gap. It is a sealed unit made of glass.

d. Install the new spark gap, placing the red tip into the recess.

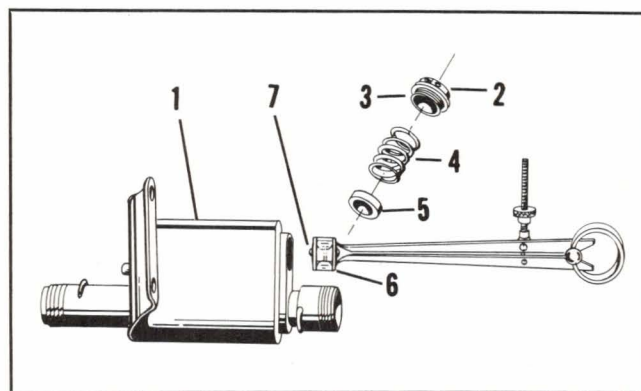
e. Replace the spacer washer.

f. Replace the plug with its spring and copper washer.

g. Tighten the plug to 10 pound-feet.

2-264. INSTALLATION.

a. Secure the replacement unit with bolts, lockwashers, and nuts.



- | | |
|------------------|------------------|
| 1. Transformer | 5. Spacer Washer |
| 2. Plug | 6. Spark Gap |
| 3. Copper Washer | 7. Red Tip |
| 4. Spring | |

Figure 2-52. Transformer Spark Gap

b. Connect the high-tension shielded lead and the ignition harness lead to the transformer.

2-265. IGNITER PLUGS.

2-266. An igniter plug is mounted in combustion chambers No. 7 and 14. Each igniter plug consists of a high-tension electrode in a porcelain bushing with a metal shell which shrouds the ceramic at the firing end to protect the insulator from thermal shocks. (See figure 2-16.)

2-267. REMOVAL.

a. Place the aircraft ignition switch *OFF*.

CAUTION

Serious personal injury will result from contact with an energized igniter plug.

b. Disconnect the igniter plug lead at the igniter plug.

c. Remove the two mounting nuts.

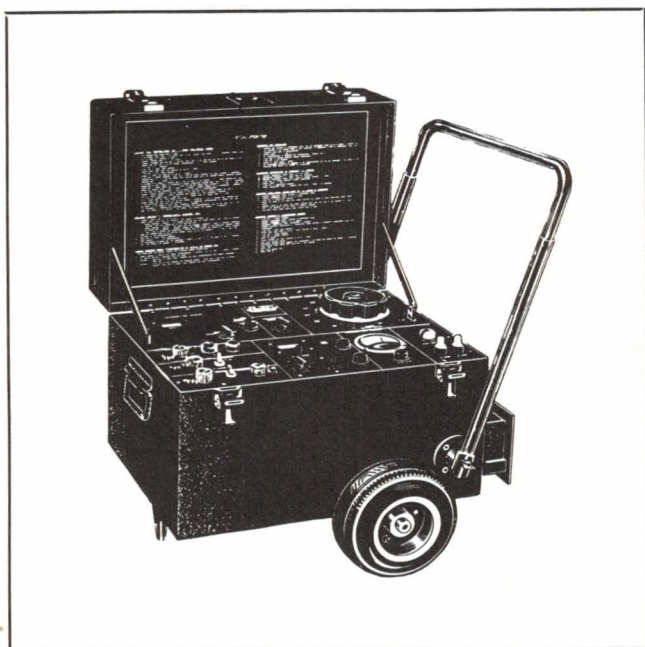
d. Remove the igniter plug and gasket.

2-268. MAINTENANCE.

a. Remove carbon from the igniter plug by sandblasting. It is not necessary to remove discoloration from the ceramic, which may be injured by excessive sandblasting.

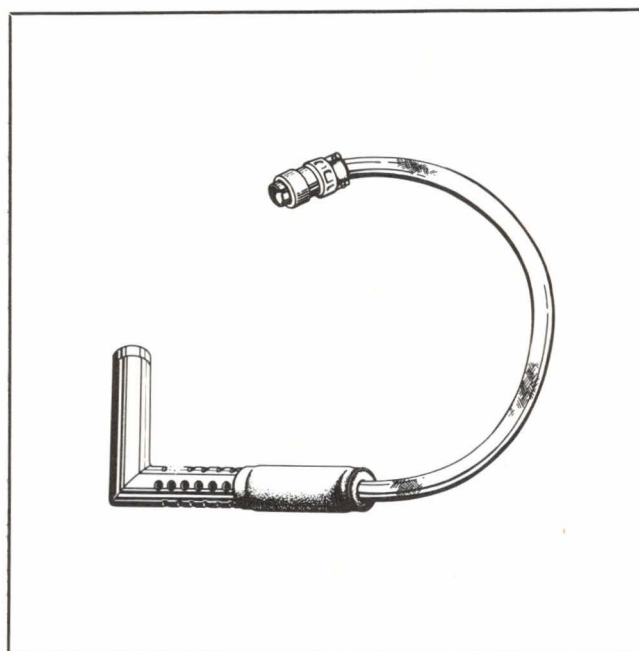
b. Check the electrode gap and set it to 0.070-0.080 inch. Do not allow the gap to exceed 0.150 inch before resetting. During engine operation the electrodes become rounded. This condition is natural and does not affect the performance of the igniter plug unless the gap becomes too wide.

c. Creepage-gap plugs cannot be regapped. When the electrode becomes shorter than the ceramic, replace the plug.



95468

Figure 2-53. Jetcal Analyzer BH112J



84843

Figure 2-54. Thermocouple Heater Probe No. 7082

2-269. INSTALLATION. Install in reverse of removal.

2-270. TESTING.

a. After the plugs have been cleaned and inspected, mount the plug in an approved high-voltage ignition tester and increase the voltage until the 15-20 kilovolt limit is reached.

b. If an igniter plug tester is not available, attach a high-tension lead to the plug and immerse the plug tip in a high dielectric oil so that about $\frac{1}{8}$ inch of the ceramic tip is covered by the oil. Apply 15-20 kilovolts across the plug. If no sparking or arc-over is observed between the ceramic and the ground shell, the igniter plug is satisfactory. Igniter plugs are unsatisfactory if there is any evidence of breakdown through the ceramic insulator.

Note

Use transformer oil for the above alternate test. If this is not available, use castor oil, kerosene filtered through silica gel, or a high grade of motor oil.

2-271. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{1}{4}$ -28	Nuts	Igniter plug retaining	70-85 lb in.
$\frac{3}{4}$ -20	Nuts	Igniter coupling	50-70 lb in.
$\frac{7}{8}$ -20	Nuts	Ignition coupling	70-90 lb in.

2-272. THERMOCOUPLE LEAD (J33-A-20.)

2-273. Chromel and alumel leads complete the circuit from the thermocouple terminal block located on the exhaust cone to the aircraft connection.

2-274. REMOVAL.

a. Disconnect the thermocouple lead connections at the aircraft disconnect.

b. Disconnect the lead electrical connections at the thermocouple terminal block.

c. Remove all clamps.

d. Pull the harness forward through the air baffle hole and remove from the engine.

2-275. INSTALLATION. Install in reverse of removal, being careful to pad the lead with glass-fiber tape at points where clamps are installed. Install clamps last.

2-276. TESTING. (Tool Group No. 7.) Use the analyzer or equivalent to test the thermocouple system. Follow the instructions provided with the analyzer. (See figures 2-53 and 2-54.) The engine part of the thermocouple system must have a minimum resistance of 1000 ohms. If the resistance is less than this, operate the engine to dry out the leads and make another check.

2-277. THERMOCOUPLE LEAD (J33-A-10A.)

2-278. Chromel and alumel leads complete the circuit from the thermocouple harness located on the exhaust unit to the aircraft connection. (See figure 2-55.)

2-279. REMOVAL.

a. Disconnect the thermocouple lead and harness wires from the terminal block located on the exhaust cone rear flange.

b. Cut the hold-down wire and remove it from the exhaust cone and the thermocouple lead.

c. Remove the nuts, washers, and screws that secure the thermocouple lead support clips to the brackets.

d. Remove the four nuts, washers, and fillister-head screws and remove the thermocouple lead junction plug from the electrical bracket at the right side of accessory housing.

e. Remove the thermocouple lead by pulling it out through the opening in the air baffle sector.

2-280. **INSTALLATION.** Install in reverse of removal, being careful to pad the lead with glass-fiber tape at points where clamps are installed. Install clamps last. Using 7½ feet of 0.032 inch lockwire, make a single loop around the thermocouple lead and then fasten the wire around the exhaust cone to remove slack and to hold down the lead wire.

2-281. **TESTING.** (Tool Group No. 7.) (Refer to paragraph 2-276.)

2-282. THERMOCOUPLE HARNESS (J33-A-10A.)

2-283. The thermocouple harness completes the circuit between the thermocouple junction blocks and the terminal block.

2-284. REMOVAL.

- a. Disconnect the harness from the lead at the terminal block.
- b. Disconnect the harness from the thermocouple leads at the junction blocks.
- c. Remove the harness.

2-285. **INSTALLATION.** Install the harness in reverse of removal, being sure to wrap leads with glass-fiber tape at all points where clamps are installed. Install clamps last.

2-286. **TESTING.** (Tool Group No. 7.) (Refer to paragraph 2-276.)

2-287. THERMOCOUPLES (J33-A-10A.)

2-288. The three thermocouples are equally spaced around the exhaust cone. All three of the thermocouples are connected in parallel by the harness.

2-289. REMOVAL.

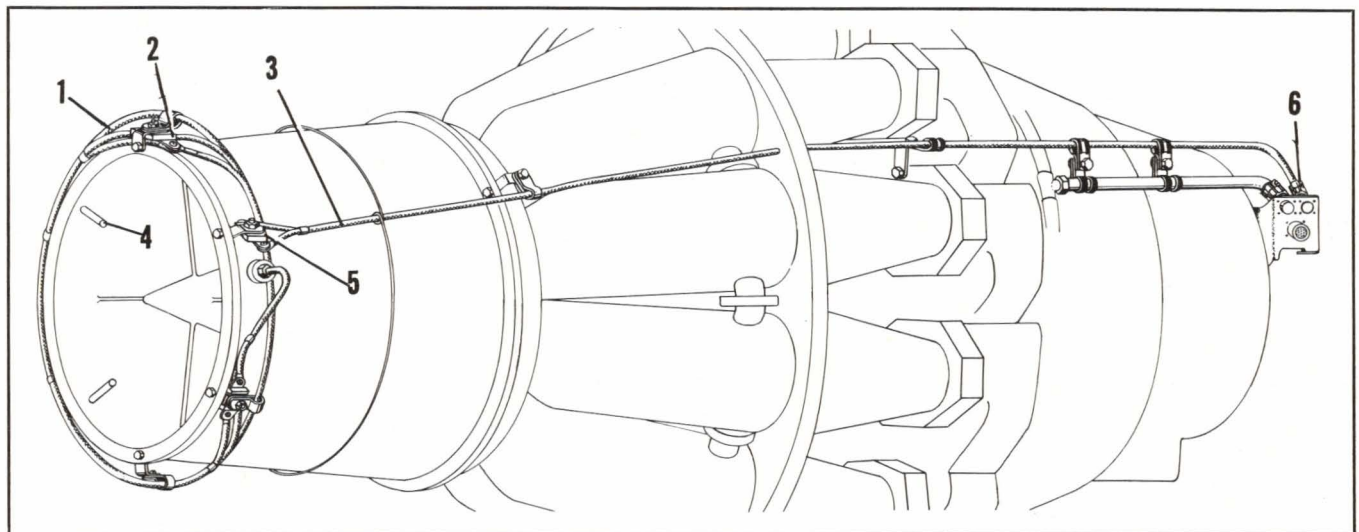
- a. Disconnect the thermocouple leads from the harness at the junction blocks.
- b. Unscrew the thermocouple gland nuts and remove the thermocouple.

2-290. **INSTALLATION.** Apply Ab-lube to the male threads of the thermocouple coupling nut. Install in reverse of removal. The chromel lead is the longer one.

2-291. **TESTING.** (Tool Group No. 7.) The resistance of each thermocouple must be at least 3000 ohms.

2-292. TORQUE LIMITS.

Size	Name	Location	Torque
¾-16	Nut	Thermocouple mounting	35-50 lb in.



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- | | |
|-------------------------|-----------------------|
| 1. Thermocouple Harness | 4. Thermocouple |
| 2. Terminal Block | 5. Junction Block |
| 3. Thermocouple Lead | 6. Aircraft Connector |

Figure 2-55. Thermocouple Installation (J33-A-10A)

SECTION III

PERIODIC INSPECTION

3-1. GENERAL.

3-2. The work in this section consists of periodic inspection and the maintenance associated with it. Detailed procedures, inspection limits, torque limits, and lubrication specifications are contained in Section II. The work can be accomplished with authorized hand tools; special tools are listed in Section I.

3-3. The inspection times in the schedule are hours of engine operation. Do not remove the engine for the 30-hour inspection; remove it for the 60-hour one. At 90 hours perform the 30-hour inspection and at 120 hours perform the 60-hour inspection; continue to alternate the inspection procedures at intervals of 30 hours.

3-4. SCHEDULE OF INSPECTIONS.

Note

Make starred inspections before each flight when more than one flight is made in the same day.

COMPONENT	INSPECTION	TIME	REMARKS
Engine (general)	Check for fuel and oil leakage; check vents and drains for obstruction. Operate the engine; check instrument readings; make an emergency fuel system check-out.	Preflight	
	Check for damage and fuel and oil leakage; check electrical wiring for burning, chafing, loose connections, or broken wires.	Postflight	
	Check for leakage of fuel and oil; check for loose or missing studs, bolts, and clamps.	60 hours	
	Remove the engine and replace it after inspection.	120 hours	
	Check the turbine wheel, turbine nozzle, inner liners, and exhaust cone for damage; check for possible cause of overtemperature.	Overtemperature operation. (See table I.)	(Refer to paragraphs 2-122, 2-127, and 2-135.)
Aircraft air inlet ducts	*Check for foreign objects.	Preflight	
	Check for loose screws and rivets.	Postflight	
Mounting bolts	Check all mounting and support bolts to make sure they are tight, safetied, and in good condition.	Postflight	
Accessories	Check for leaking and insecurity of mounting.	Postflight	
	Measure upper idler gear looseness.	120 hours	(Refer to paragraph 2-75.)
Compressor rotating guide vanes	Inspect for nicks, dents, and cracks exceeding permissible limits.	120 hours	(Refer to paragraph 2-86.)

COMPONENT	INSPECTION	TIME	REMARKS
Compressor fixed inlet guide vanes	Check for loose mounting screws; check for crack progression.	120 hours	(Refer to paragraph 2-90.)
Diffuser turning vanes	Check for looseness.	120 hours	(Refer to paragraph (2-95.)
Diffuser	Inspect for compressor air leaks.	240 hours	(Refer to paragraph 2-96.)
Compressor shims	Inspect for shim protrusion.	120 hours	(Refer to paragraph 2-97.)
Trust rings	Tighten compressor diffuser-to-truss ring split line nuts.	120 hours	(Refer to paragraph 2-102.)
Air adapters	Clean air adapters, domes, and fuel filters; inspect for cracks and weld failures; replace faulty fuel nozzles.	120 hours	
Air sectors and combustion chambers	Check air sectors for cracks. Check for evidence of chafing of combustion chambers.	60 hours	(Refer to paragraph 2-114.)
Combustion chambers	Inspect for cracks, warping, and hot spots.	Whenever aircraft tailpipe is removed and 60 hours.	(Refer to paragraph 2-114.)
Inner liners	Remove and inspect for cracking or buckling. Replace all liners exceeding limits.	120 hours	(See figure 2-23.)
Ring and tube gusset plates	Inspect for cracks.	100 hours	(Refer to paragraph 2-115.)
Turbine section	Check for missing or broken blades, using a strong light. Motor the engine to listen for turbine wheel contact with adjacent surfaces.	Postflight	Do not damage exhaust gas thermocouples when entering the tailpipe.
Turbine cooling air inlet screens	Inspect the turbine cooling air screens for clogging. Remove all foreign material.	60 hours	
Turbine wheel, turbine nozzle, and exhaust unit	Check the axial clearance between the turbine wheel and the inner exhaust cone; check the radial clearance between the blade tips and the inner diameter of the turbine shroud; examine the blades with a light for damage; check the turbine wheel for rubbing or scraping; inspect non-pinned turbine nozzles for cracks.	60 hours	(Refer to paragraphs 2-127, 2-134, 2-156, and 2-161.)
	Inspect the turbine nozzle and turbine wheel for cracks; inspect turbine blades. Inspect the turbine wheel blade slots for serration cracks.	Whenever the turbine wheel is removed and at 120 hours	(Refer to paragraphs 2-127 and 2-137.
Exhaust section	*Check for accumulation of fuel and oil.	Preflight	
Exhaust cone	Using a strong light, check for soot swirls, hot spots, or discoloration indicating faulty fuel nozzle.	Postflight	
	Inspect the exhaust cone inner area for heat streaks and excessive warping.	60 hours	(Refer to paragraph 2-161.)
	Inspect for cracks in the inner cone flange.	240 hours	(Refer to paragraph 2-161.)

COMPONENT	INSPECTION	TIME	REMARKS
Fuel system	Check for insecurity and leaking.	Postflight	Check with boost pumps ON.
Fuel pump	Remove, inspect, and lubricate the splines.	120 hours	(Refer to paragraph 2-173.) Use Ab-lube.
Fuel filter	Remove and clean filter. Replace ring seal.	60 hours	(Refer to paragraph 2-178.)
	Clean the filter and replace the ring seal. Metal particles in the filters during the first 50 hours of new or replacement pump operation are not cause for pump removal.	5 hours after installing a replacement engine or after replacing pump.	(Refer to paragraph 2-178.)
Main fuel control	Inspect all rod end bearings for freedom of motion.	Postflight	These bearings are at each end of the rod connecting the cutoff valve and governor valve of the main control.
	Lubricate each rod end bearing.	60 hours	Use MIL-O-6081 (grade 1010.)
Drip valve	Check for leaks.	Postflight	Check with boost pumps ON.
Throttle lever	*Check for freedom of operation and full travel; check for security of linkage.	Preflight	
Oil supply	*Check for adequate supply.	Preflight	
	Change oil.	390 hours	
Oil pump	Inspect inlet screen for damage.	120 hours	
Oil filter	Clean oil filter. Replace gasket.	120 hours	
Starter	Check the motor for dirty or loose connections.	120 hours	(Refer to paragraph 2-246.)
Generator	Inspect the brushes for uneven wear, binding in the brush holder, and incorrect length. Examine the commutator for badly blackened or pitted bars.	120 hours	(Refer to paragraph 2-253.)
	Remove and lubricate the splines.		(Refer to paragraph 2-30.)
Generator and starter	Check the generator and starter for cracked or broken mounting flanges, air inlet castings, or terminal blocks. Inspect the mounting nuts and electrical connections for insecurity.	60 hours	
Igniter plugs	Check operation.	Postflight	
Igniter plugs (Part No. 6728646)	Inspect for carbon deposits.	10 hours	(Refer to paragraph 2-265.)
Igniter plugs	Remove questionable plugs; clean and test.	120 hours	(Refer to paragraph 2-265.)

SECTION IV

PRESERVATION AND STORAGE

4-1. GENERAL

4-2. This section provides instructions for engine preservation, storage, maintenance in storage, renewal, and depreservation.

CAUTION

If the engine is preserved installed in an aircraft, take care to avoid spilling fuel and oil into the fuselage.

4-3. RECORDS. Record in the log book all preservations, renewals of preservation, depreservations, and all inspections.

4-4. CLEANING. Use dry-cleaning solvent Specification P-S-661 for hand-cleaning exterior surfaces to which corrosion-preventive compounds are to be applied. Be sure to remove all fingerprint traces from critical metal surfaces; wipe the surface with a cloth containing fingerprint remover conforming to Specification MIL-C-15074, and then wipe with a cloth containing Specification P-S-661 solvent.

4-5. REQUIRED MATERIALS AND EQUIPMENT.

a. Preserve the lubricating system by using a mixture of one part by volume of corrosion-preventive compound conforming to Specification MIL-C-6529, type I, and three parts of lubricating oil conforming to Specification MIL-O-6081, grade 1010; or use Specification MIL-C-6529, type III, which is a pre-mixed compound.

Note

Engine operation is permitted for a maximum of 10 hours using Specification MIL-C-6529, formula A or B, type III, oil as an engine lubricant.

b. Store humidity indicator cards and bags containing dehydrating agents in sealed containers to prevent absorption of atmospheric moisture.

c. These are the materials and equipment required to accomplish complete preparation for storage:

<i>Item</i>	<i>Use</i>	<i>Specification</i>	<i>Quantity</i>
Corrosion-preventive mixture consisting of:	Lubrication system		
Corrosion-preventive compound (one part) and		MIL-C-6529 (type I)	
Lubricating oil (three parts) or		MIL-O-6081 (grade 1010)	
Corrosion-preventive compound		MIL-C-6529 (type III)	
Flushing oil	Fuel system	MIL-O-6081 (grade 1010)	
		MIL-C-6708	
Corrosion-preventive compound	Container closure bolts		
Corrosion-preventive compound	Unexposed surfaces	MIL-C-16173A (grade 3)	
Corrosion-preventive compound	Exterior surfaces	MIL-C-16173A (grade 2)	
Dry cleaning solvent	Metal surfaces	P-S-661	
Fingerprint remover	Exterior surfaces	MIL-C-15074	
Dehydrating agent	Engine container	MIL-D-3464	240 units
Dehydrator plug		AN4062-1	1
Humidity indicator card		6738255	1
Container	Engine	6713999	1
Rear bracket mount assembly	Exhaust cone front flange	6714559	2
3/8-24 x 1 11/16 bolt		AN101321	8 each
3/8-24 nut		AN365-624	8 each

Item	Use	Specification	Quantity
Fiberboard carton 6 x 3 x 3	Drain valve, exhaust cone bolts and nuts, starter pinion (-20)		1
Vynlite cover 5/16 x 18 x 5/8	Exhaust cone	6708771	1
	Thermocouple brackets to exhaust cone		(-10A) 6 each (-20) 4 each
5/16-18 hexagonal nut			(-10A) 6 each (-20) 4 each
Cover	Starter and generator drive flange		(-20) 2 each
5/16-20 aluminum alloy plug	Fuel pressure opening	AN814-14D	1 each
0.365 ID rubber gasket		6703703	1 each
5/16-20 aluminum alloy plug	Drip valve	AN814-14D	1 each
0.365 ID rubber gasket		6703703	1 each
5/16-20 plastic plug	Drain valve	6706532	2 each
5/16-20 plastic plug	Combustion chamber drain, oil pressure opening, aneroid bellows cover, main fuel control seal drain	6706532	
5/16-20 aluminum alloy cap	Fuel pump drain	AN929-4	1 each
1 7/8-12 plastic cap	Main fuel inlet	6709648	1 each
1 inch ID rubber cap	Accessories gear case vent		1 each
Plug	Ignition harness connection (-20)	6735707-16	1 each
Plug	Fuel flowmeter connection (-20)	6735707-17	1 each
Plug	Fuel and oil pressure transmitter (-20)	6735707-19	2 each
Plug	Main electrical connection (-20)	6735707-28	1 each

Note

At the time of use, corrosion-preventive compounds should be water-free and at least 60°F.

4-6. STORAGE FOR LESS THAN 14 DAYS.

4-7. **PRESERVATION.** Using the lubricant specified for the engine, operate the engine for 10 minutes at 75% speed (8810 rpm). Seal all engine openings to keep out water, salt spray, and foreign material.

4-8. **RENEWAL OF PRESERVATION.** This preservation may not be renewed.

4-9. **DEPRESERVATION.** No depreservation is required.

4-10. STORAGE FOR 14-119 DAYS.

4-11. All operable engines which are to remain inoperative for 14-119 days should be treated as outlined below.

4-12. **PRESERVATION.**

a. Preserve the engine lubrication system in accordance with paragraph 4-17.

b. If the engine is to be stored for less than 28 days, be certain the fuel system is filled; no other fuel system preservation is necessary.

c. If the engine is to be stored for more than 28 days, preserve the fuel system. (Refer to paragraph 4-18.)

d. Close all engine openings.

4-13. **MAINTENANCE IN PRESERVATION.** Every 28 days use the following procedure:

a. Remove the inlet and exhaust covers. Open the engine fuel inlet and remove the pressure-sensing connection from the starting control. Put 12 quarts of corrosion-preventive mixture in the oil tank and motor the engine without ignition for 3 minutes.

CAUTION

If the starter is used for motoring, its limits must not be exceeded.

b. Drain the oil from the engine and re-install connections and covers.

4-14. **RENEWAL OF PRESERVATION.** Storage may not be renewed unless the engine is depreserved and given a ground check run. Only one renewal is permitted.

4-15. **DEPRESERVATION.** Depreserve the oil and fuel systems. (Refer to paragraphs 4-24 and 4-25.) If the fuel system was stored filled with fuel, no depreservation is required except circulating fuel by motoring the engine without ignition.

4-16. EXTENDED STORAGE.

4-17. **PRESERVATION RUN.** Make a preservation run before removing the engine from the airframe or test stand and as soon as it is decided to preserve the engine. If it is impossible to make a preservation run, preserve the engine as an inoperable one (refer to paragraph 4-27) and send it to an activity where the run can be made. Perform the following steps immediately after stopping the engine:

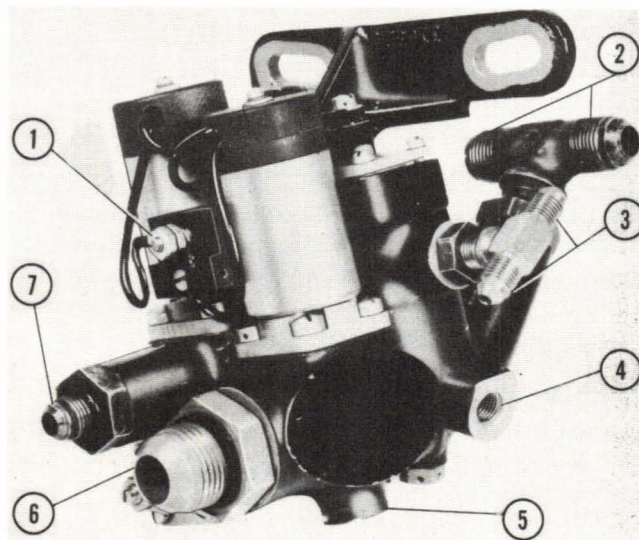
a. Remove the drain plug from the bottom of the accessories gear casing; drain and replace plug. Fill the oil reservoir with 12 quarts of corrosion-preventive mixture.

b. Operate engine for 10 minutes at approximately 75% speed (8810 rpm).

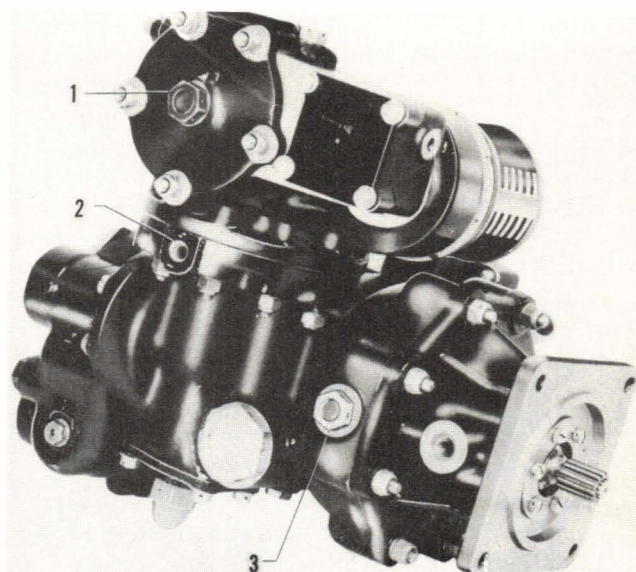
c. Shut down the engine and remove the oil filter and clean it. Spray with corrosion-preventive mixture, and reinstall on engine.

4-18. PRESERVATION OF THE FUEL SYSTEM.

- a. Remove, clean, and replace fuel filters.
- b. Disconnect the main fuel manifold lines at the starting fuel control. Disconnect No. 7 and 14 fuel nozzle lines at the starting control. Provide hose and drain pans for these openings. (See figure 4-1.)
- c. Remove the plugs in the drip valve and the pressure-sensing connection of the starting fuel control. Energize the starting fuel control solenoid and place the throttle in cutoff.
- d. Remove the density chamber drain, the governor weight spin chamber drain (see figure 4-2), and the bleeder plug from the bypass cover of controls which have this plug. Arrange to catch fluid from these openings.
- e. Replace the governor weight spin chamber plug after it drains.
- f. Attach an oil supply of Specification MIL-O-6081, grade 1010, to the engine fuel inlet fitting through a 10-micron filter at 20 psi.
- g. Motor the engine without ignition and bring it up to cranking speed.
- h. Simultaneous with motoring open the oil supply (MIL-O-6081, grade 1010) line to the engine and open the throttle.
- i. During motoring and coast-down open and close the throttle 10 times. Intermittently energize the starting control solenoid to ensure flushing of the starting control system.
- j. Flushing is complete when fuel-free oil is observed coming from the drains.
- k. Replace plugs and reconnect lines after the system drains.



- | | |
|--|---|
| 1. Electrical Connection | 5. Drip Valve Drain Connection |
| 2. Outlets to Main Fuel Manifold | 6. Inlet from Main Double Check Valve |
| 3. Outlets to Combustion Chambers No. 7 and 14 | 7. Inlet from Starting Double Check Valve |
| 4. Fuel Pressure-sensing Connection | |

Figure 4-1. Starting Fuel Control

1. Density Chamber Drain
2. Regulator Drain
3. Governor Weight Spin-chamber Drain

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Figure 4-2. Main Fuel Control—Bottom View

1. Attach a tag to the engine fuel inlet fitting which reads "This fuel system has been prepared for storage by flushing with oil conforming to MIL-O-6081, grade 1010." Date the tag.

4-19. COMPLETING PRESERVATION. Before packing the engine in a metal container for preservation, follow this procedure:

- a. Carefully disconnect the thermocouple lead at the exhaust cone (J33-A-10A) and tape or tie it to the engine so that loops are no smaller than 12 inches in diameter. Smaller loops will distort the inner insulation and break the outside metal braid.
- b. Remove all aircraft-furnished fittings from the engine and seal the openings with tape, paper, and approved plugs, covers, or caps. Remove any engine-driven accessory which will not remain installed on the engine on the normal mounting pad during the storage period. Preserve the drive by coating it thoroughly with corrosion-preventive mixture and close the opening with a cover. Separately preserve the removed accessories in accordance with the applicable instructions.

4-20. SHIPMENT BY AIR. When engines are to be shipped by air, use the universal air shipping stand, stock number R85-TEL-52A003, whenever possible. (Refer to NavAer 19-15-501, dated 15 June 1955.)

4-21. INSTALLATION IN THE SHIPPING CONTAINER.

- a. Inspect the shipping container for dirt, internal dampness, and damage from handling. The container must be free of water, oil, or other foreign material.

Check the closure flange mating surfaces and the gasket. Do not use any sealing material on the gasket.

CAUTION

Never use the engine sling or engine hoist fittings to lift an engine which is attached to the lower half of the container only.

b. Mark the lower half of the container on the inside, where it will be visible when the top half is off, with a stencil reading:

DO NOT LIFT THE ENGINE CONTAINER TOGETHER WITH THE ENGINE USING ENGINE SLING OR ENGINE HOIST FITTINGS.

c. Beginning with the top center exhaust cone mounting bolt as No. 1 remove the bolts and nuts at positions 11, 12, 18 and 19. Attach two rear shipping support mounting brackets to the exhaust cone flange. Use shipping bolts and self-locking nuts. (Refer to paragraph 4-8.)

d. Attach a tag to the top front of the exhaust cone flange which reads: "Exhaust cone mounting brackets are attached with shipping bolts and nuts. Engine bolts and nuts are packed separately."

e. On the J33-A-10A engine wrap the exhaust cone mounting bolts and the engine fittings in oil-proof paper and attach them to the No. 12 fuel manifold line. Label the package to show its contents.

f. Remove the right trunnion spindle set screw and trunnion spindle bolt.

Note

Thoroughly coat the outside diameter and threads of the trunnion spindle and the inside diameter and threads of the trunnion support with Ab-lube.

g. Assemble the right side frame bracket by inserting the rear support bracket mounting bolt through the forward elongated hole at the rear end of the side frame bracket. Place a lockwasher and nut on the bolt but do not tighten. Assemble the right trunnion spindle bolt through the side frame bracket to the engine trunnion mount and tighten to 100-110 lb ft. Re-install the trunnion spindle set screw and tighten to 100-110 lb in.

CAUTION

Make sure the trunnion spindle set screw is not tightened beyond its specified torque.

Tighten the nut on the rear mounting bracket bolt. Assemble the left side frame bracket using the same procedure.

h. Attach tags to the trunnion spindle bolts which read "Warning—Remove $\frac{5}{16}$ -18 trunnion spindle set

screw from trunnion support before removing or replacing a trunnion spindle bolt."

i. Install the engine in the container; fasten the side frame brackets to the container mounting supports with bolts, nuts and lockwashers.

j. Remove nuts from the accessories unit retaining bolts and remove the accessories unit. Place 240 units of dehydrating agent in the dessicant receptacle and then re-install the accessories unit in the container.

k. Install a humidity indicator plug in the accessories unit and tighten to 20-25 lb in.

l. Carefully lower the container cover over the engine and align with the guide pin. Install flange bolts and nuts; tighten to 95-105 lb. ft. Tighten both sides progressively from the center of the container to each end.

m. When all closures are sealed pressurize the container to 5 psi internal pressure through the container filler valve. Use clean compressed air free of liquid water.

Note

Use only pressure gauges which are graduated in pounds per square inch and with a range of not more than 15 psi.

n. Check the container split line and the accessories unit for leaks using a soap-water solution. No leaks are permitted. After one hour check the internal pressure and closure bolts torque.

o. Coat the container closure bolts and nuts with Specification MIL-C-6708 corrosion preventive compound.

p. Mark the container in accordance with applicable instructions. Make appropriate entries in the engine records; place the records in the container records receptacle and replace the cover.

4-22. **MAINTENANCE IN PRESERVATION.** Inspect the pressure and the internal relative humidity of the engine shipping container immediately before shipment, upon receipt, and at least once every ninety days.

a. If the internal pressure is more than 1 psi and if the humidity indicator shows a safe condition, no further maintenance of the engine or container is required until the next inspection.

b. If the internal pressure is less than 1 psi and if the humidity indicator shows safe, re-pressurize the container to 5 psi; use clean compressed air free of liquid water. Re-check the pressure after seven days. If the pressure has not been maintained, use the engine or re-install it in another container. Forward the faulty container to a suitable repair activity.

c. If the humidity indicator shows an unsafe condition, remove the engine from the container and inspect it for evidence of corrosion. If the engine is safe for running and if the local conditions permit, de-preserve the engine and make a ground run-up check to determine whether the engine operates within limits.

4-23. **RENEWAL OF PRESERVATION.** The engine must be removed from the container, depreserved, and given a depreservation run. It then may be represerved for the desired period.

4-24. **DEPRESERVATION.**

CAUTION

Release the air pressure from the container at the filler valve before removing the closure bolts.

a. The upper part of the engine shipping container is a cover which is held to the lower part by bolts. Lift the cover straight up in order not to damage any part of the engine.

b. Remove the dehydrating agent bags from the engine.

c. Detach the brass plug from the dehydrator plug. Remove the dehydrator plug from the accessories gear case and install the brass plug in its place. Safety the plug.

d. Remove the shipping cover and gasket from the exhaust cone outlet.

e. Remove protective covering from exhaust cone thermocouples on J33-A-10A engines.

f. Remove the combustion chamber drain valve from its attached position on the engine. Unwrap the drain valve and install it in the aircraft.

g. Remove the engine fuel inlet fitting from its attached position on the engine. Unwrap the fitting and install it in position.

h. Remove the plug, cap, or cover from each of the openings where aircraft connections are to be made. Install permanent closures on any engine opening to which an aircraft connection is not made.

i. Remove lockwire from the main control lever.

j. Remove, clean, and re-install the oil filter and scavenge oil filter. (Refer to paragraph 2-225 and figure 2-46.)

k. Drain the accessories gear casing and replace the plug. Fill the oil reservoir with 12 quarts of oil specified for engine lubrication. Bleed air from the oil lines.

4-25. **DEPRESERVATION OF THE FUEL SYSTEM.**

a. Perform the steps in paragraph 4-18 a through e.

b. Introduce fuel at 20 psi through a 10-micron filter into the engine fuel inlet opening.

c. Simultaneous with fuel admission, motor the engine without ignition up to cranking speed.

CAUTION

Make sure there is an indication of oil pressure before continuing motoring. Do not exceed starter limitations.

d. Open and close the throttle several times, pausing briefly at each extreme position. Intermittently energize

the starting control during motoring to ensure flushing.

e. After coastdown allow fuel to drain from the engine. Remove the governor weight spin chamber plug for draining.

f. Drain the fuel filters; replace and lockwire plugs and restore all connections.

g. Fill the main control with fuel. Loosen the fuel line connections at the bypass outlet and bleed air out of the bypass line.

h. Let the control stand for an eight-hour soaking period before operating the engine.

CAUTION

The fuel control requires a few hours operating time to provide stable operation.

4-26. **COMPLETING DEPRESERVATION.**

a. Operate the engine at 38-47% speed (4465-5525 rpm) for five minutes.

b. Stop the engine.

c. Remove, clean, and re-install the oil filter and scavenge oil filter.

d. Check the main fuel control throttle setting. (Refer to paragraph 2-62.)

4-27. **PRESERVATION OF INOPERABLE ENGINES.**

4-28. This procedure applies to inoperable engines being sent to overhaul or repair.

4-29. **PRESERVATION WHEN ROTOR SHAFT CAN BE ROTATED.**

a. Remove the magnetic drain plug from the bottom of the accessories gear casing. Allow oil to drain. Reinstall the drain plug.

b. Fill the oil reservoir with 12 quarts of corrosion-preventive compound mixture.

c. Turn over the engine at 5-10% speed (590-1175 rpm) for 15 minutes, using external power such as compressed air. Do not use the starter for this run.

d. Preserve the remainder of the engine and its accessories in accordance with the preservation requirements of extended storage. (Refer to paragraph 4-16.)

4-30. **PRESERVATION WHEN ROTOR SHAFT CANNOT BE ROTATED.**

a. Disconnect sufficient oil lines to permit generous quantities of corrosion-preventive compound mixture to be forced into the bearings.

b. Preserve the fuel system in accordance with paragraph 4-18 with these exceptions: do not motor; disconnect lines from the fuel pump to the control; plug the lines to the pump. Introduce Specification MIL-O-6081, grade 1010, oil into the control at 25 psi through a 10-micron filter with the throttle open.

c. Allow the corrosion preventive to drain. Reconnect lines; replace and lockwire drains.

d. Tag the engine fuel inlet fitting. (Refer to paragraph 4-18.)

e. Complete preservation (refer to paragraph 4-19) and install engine in shipping container (refer to paragraph 4-21).

4-31. MAINTENANCE IN PRESERVATION.

- a. Expedite transfer to a repair activity.
- b. Maintain preservation in accordance with extended storage requirements if possible.

4-32. PRESERVATION AFTER WATER IMMERSION.

4-33. Perform the following steps as soon as possible after recovering the engine.

- a. Wash the outside of the engine and remove all traces of salt. Remove the accessories and disassemble the engine as far as necessary to wash all interior surfaces which have had water on them. Wash the engine with steam if possible; hot fresh water or fresh water are alternates.

- b. If one is available, use a drying oven to dry the engine parts at 93°C (200°F). If this is not possible, pour out and wipe the parts and dry them with an air blast.

- c. Immerse the dried parts in thin-film rust preventive Specification MIL-C-16173A, grade 3. Allow the parts to drain. Then coat all unpainted surfaces with corrosion preventive specified in paragraph 4-8; do not

apply this preventive to the exhaust cone except the mounting flanges.

- d. Flush the fuel system with oil, Specification MIL-O-6081, grade 1010.

- e. Flush the oil system—especially the main bearings—with corrosion-preventive mixture.

- f. Assemble the engine parts. Tighten retaining bolts and nuts only enough to hold the parts during shipment; usually finger-tight is adequate.

- g. Pack the engine in a shipping container marked "Water immersion engine—priority handling required."

4-34. DIMENSIONS AND WEIGHTS.

4-35. The engine shipping container is 125 inches long, 65 wide, and 69 high.

4-36. Each box weighs approximately 2050 pounds empty and 4000 pounds completely packed for shipment. Ship metal engine containers with the longitudinal axis parallel to that of the carrier.

SECTION V

MINOR REPAIR

5-1. GENERAL INSTRUCTIONS.

5-2. The minor repair in this section describes operations possible at Class C maintenance. The information is divided into dismantling and disassembly; cleaning, inspection and repair; assembly of subassemblies; final assembly; and testing. In this section is the table of limits; use this table for all measuring and gauging of mating parts. (Refer to paragraph 2-64 for general torque limits.)

5-3. If the damage to an engine cannot be repaired by Class C line maintenance, send it to a major overhaul depot. Minor repair has no effect on the engine time.

5-4. Enter in the log book the date of repair, the activity performing the work, and the major parts replaced.

5-5. Observe the precautions in paragraphs 2-6 through 2-10. In addition, follow these general procedures:

a. Keep the working area clean. Be careful to keep foreign material out of the engine; use temporary covers when possible.

b. Watch for work previously performed incorrectly; report it in accordance with current practice.

c. Use the tools recommended for each operation. When tools are modified or improved locally, report them to BuAer for possible use at all activities.

d. Disassemble the engine only as far as necessary to repair or replace the defective part.

e. Use plastic or rawhide hammers—never metal—for driving on any part of the engine. Never lift heavy parts by hand; use special lifting yokes with a chain or electric hoist. Apply tension evenly to all bearing pushers and pullers. Tighten tee handles and attaching bolts, nuts, and screws in small increments on opposite planes. Record on suitable forms all measurements taken.

f. Wire or bag together small related parts. Tag all parts with a description and the serial number of the engine they were removed from. Cover parts left un-assembled.

5-6. DISMANTLING AND DISASSEMBLY.

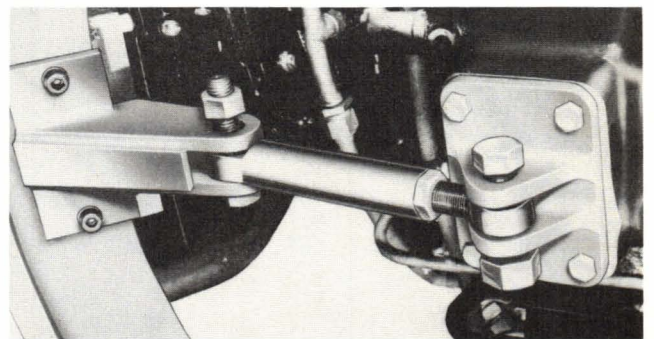
5-7. MOUNTING ENGINE IN OVERHAUL STAND (Tool Groups No. 3 and 4.)

a. Install the lifting bracket on the boss at the top of the compressor diffuser. Install the lifting bracket on the two bosses on top of the ring and tube. Fasten the lifting sling to the two brackets, and slip the hook of a chain hoist through the eye of the sling. Position the eye at the center of balance over the air adapters.

b. Unfasten the engine from the transportation stand and lower it into the overhaul stand so that the trunnions rest on the front bearing blocks. Install the bearing block caps over the trunnions and lock them in place with the attached thumb screws.

c. Install the front lift bracket on the boss at the bottom of the compressor diffuser. Position the clevis of the stand support bar over the eye on the bracket. Install the bolt and nut provided with the support bar. (See figure 5-1.) Remove the lifting brackets and sling.

d. Place a container under the drain plug on the bottom of the accessories drive casing. Remove the plug, allow the oil to drain, and replace the plug. Tighten it and lockwire.



32902
Figure 5-1. Stand Support Bar and Bracket No. 2992

5-8. REMOVAL OF THE EXHAUST UNIT.

5-9. Refer to paragraph 2-160 for removal of the exhaust unit. In addition, remove the demountable shroud ring from the rear flange of the ring and tube.

5-10. REMOVAL OF THE AIR ADAPTERS.

(Tool Group No. 2.)

a. Remove the drain lines, leaving the fittings in the air adapters.

b. Disconnect the flexible hose at the starting check valves of the No. 7 and 14 combustion chambers.

c. Disconnect the fuel manifold leads at the air adapters.

d. Disconnect the high-tension leads at the igniter plugs.

e. Remove the spacer and gaskets from between each air adapter and diffuser outlet.

f. Remove the air adapters, lifting the adapter toward the front of the engine so that the combustion dome will clear the inner liner. (See figure 5-2.) Close each opening of the ring and tube with protective covers to prevent foreign objects from entering.

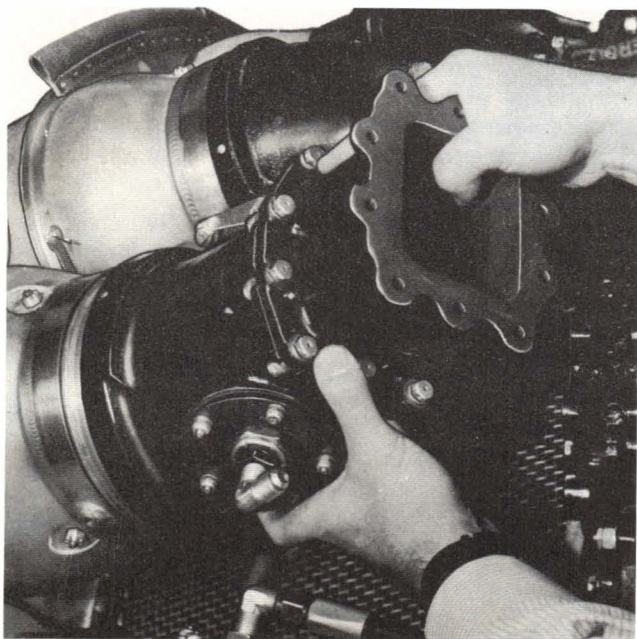
Note

If the air adapters are not numbered to correspond correctly with the number of the combustion chamber on which they are mounted, tag them for proper location at assembly.

5-11. SEPARATING THE TURBINE UNIT FROM THE COMPRESSOR.

(Tool Group No. 17.)

a. Remove the nuts and washers holding the turbine unit to the rear truss ring.



42899

Figure 5-2. Removing Air Adapter and Spacer

b. Install the rear lift on the rear flange of the turbine unit and hook a hoist to the lift. (See figure 5-3.)

Note

When positioning the lift on the ring and tube, slip the rigid leg of the lift over the flange first. The pivot leg will swing readily into position, after which the pins provided with the tool can be installed through the holes in the flange.

c. Install the stand adapter ring on the turbine unit stand, and secure it with the clamps provided. Turn the ring in the stand so that the bottom side is up.

d. Lift the turbine unit from the compressor and lower it into the adapter ring in the stand.

CAUTION

Make certain that the oil transfer tube in the turbine bearing support enters the relief hole provided in the ring.

e. Secure the turbine unit to the adapter ring. Attach sleeve nuts to the short studs on the bearing support and remove the lift. (See figure 5-4.)

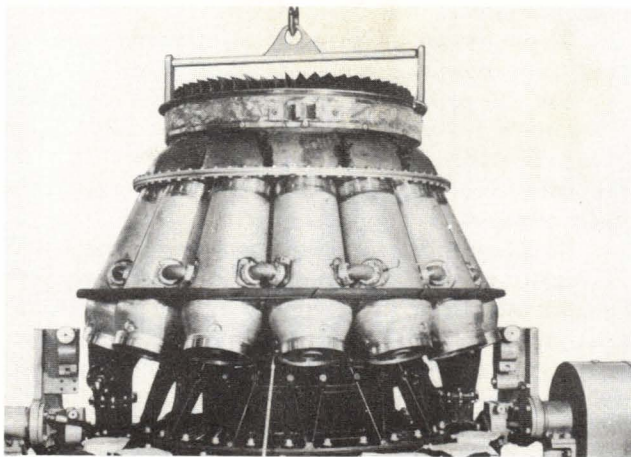
f. Turn the turbine unit in the stand so that the front end is up. Fasten a hoist and the front lift sling to the adapter ring, loosen the clamps on the stand, and remove the turbine unit from the stand.

g. Lower the unit onto the turbine rotor stand so that the rear flange of the ring and tube rests on the stand support blocks. Remove the hoist and the adapter ring.

5-12. REMOVING THE TURBINE SHAFT COUPLING SLEEVE.

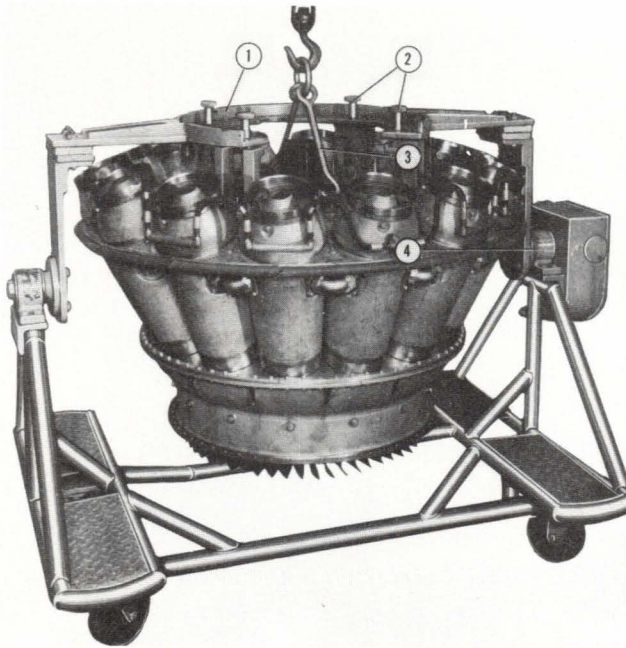
(Tool Group No. 12.)

a. Bend out the tab on the lockwasher under the retaining nut which fastens the coupling hub and sleeve to



42889

Figure 5-3. Removing the Turbine Unit from the Compressor with Lift No. 2996



1. Adapter Ring
2. Clamps

3. Sling No. 3631
4. Stand No. 3637

42613

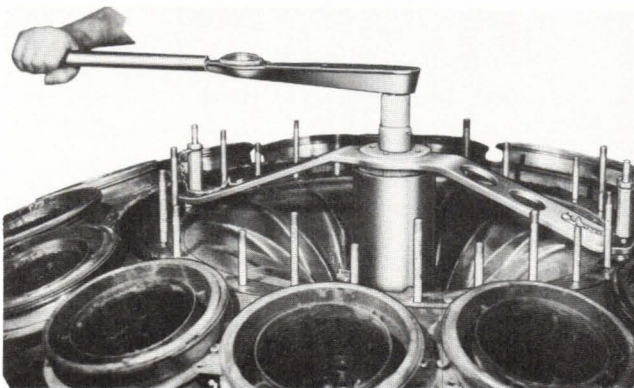
Figure 5-4. Turbine Unit in Stand No. 3637

the turbine shaft. Insert the locknut wrench and holder into the coupling sleeve, fitting the external splines of the holding fixture into the internal splines of the sleeve, and secure to the bearing support studs with the attached sleeve nuts. Engage the teeth of the wrench with the retaining nut and break the nut loose. (See figure 5-5.)

b. Remove the tool; then remove the retaining nut and tab washer by hand. Lift off the coupling sleeve and hub. If the coupling is tight on the shaft splines, use the puller to remove the coupling. (See figure 5-6.)

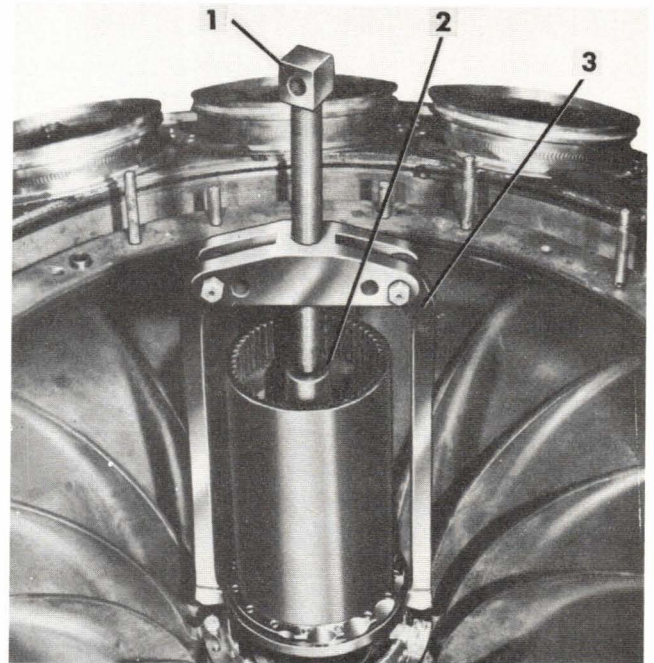
5-13. TURBINE FRONT BEARING AND CAGE. (Tool Group No. 13.)

a. Remove the seven bolts securing the adjusting nut. Remove the fillister head screw and lock plate.



32675

Figure 5-5. Removing Turbine Coupling Hub Retainer Nut with Wrench No. 2962



31930

1. Puller No. 2873
2. Plug
3. Arm No. 2873-4

Figure 5-6. Removing Coupling Hub and Sleeve from the Turbine Shaft

b. Raise the turbine and shaft slightly by turning the screw jack handle on the stand approximately one-half turn clockwise. This will free the adjusting nut on the sliding ring. If necessary use a wrench to loosen the nut and back it off approximately two turns.

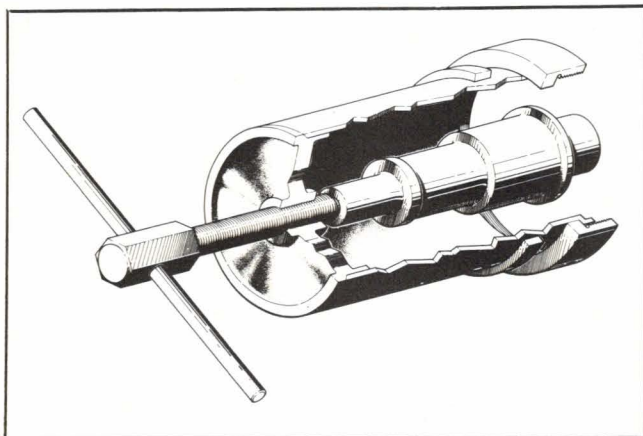
Note

If the bearing being removed is the type with the two-piece inner ring (alternate to one-piece inner ring type), proceed cautiously to avoid damage to the bearing during disassembly. As the bearing is removed, the rear half of the inner ring will remain on the shaft; therefore, the ball assembly and the front half of the inner ring may drop down when the journal is cleared. Remove the rear half of the inner ring from the shaft by using standard universal puller with a minimum of three arms and an 8½ inch reach.

c. Remove the sliding ring and bearing with the special puller. (See figure 5-7.) Remove the puller from the ring. Remove the adjusting nut from the sliding ring.

d. Remove the bearing retainer ring with compressing tool. (See figure 5-8.) Remove the bearing from the sliding ring.

e. Remove the forward bearing turbine shaft shoulder ring.



104535

Figure 5-7. Turbine Front Bearing Sliding Ring Puller No. 2969

5-14. REMOVING THE RING AND TUBE FROM THE TURBINE ROTOR.

(Tool Groups No. 16 and 17.)

- a. Install the guide sleeve on the turbine rotor shaft to prevent damage to the oil seal. (See figure 5-9.)

Note

The locating arm of the guide must enter the turbine front oil nozzle passage in the bearing support so that the guide will properly fit over the rear nozzle.

- b. Lift the ring and tube and the bearing support from the turbine rotor and shaft with a hoist. One person is required to operate the hoist while another guides the unit to prevent damage. (See figure 5-10.)

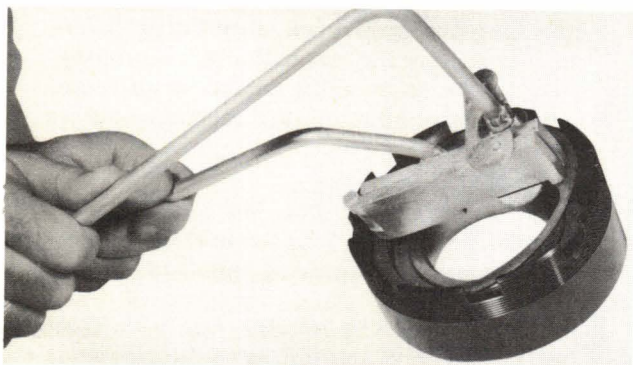
- c. Install the unit in the stand and remove the guide sleeve.

5-15. TURBINE ROTOR DISASSEMBLY.

(Tool Group No. 16.)

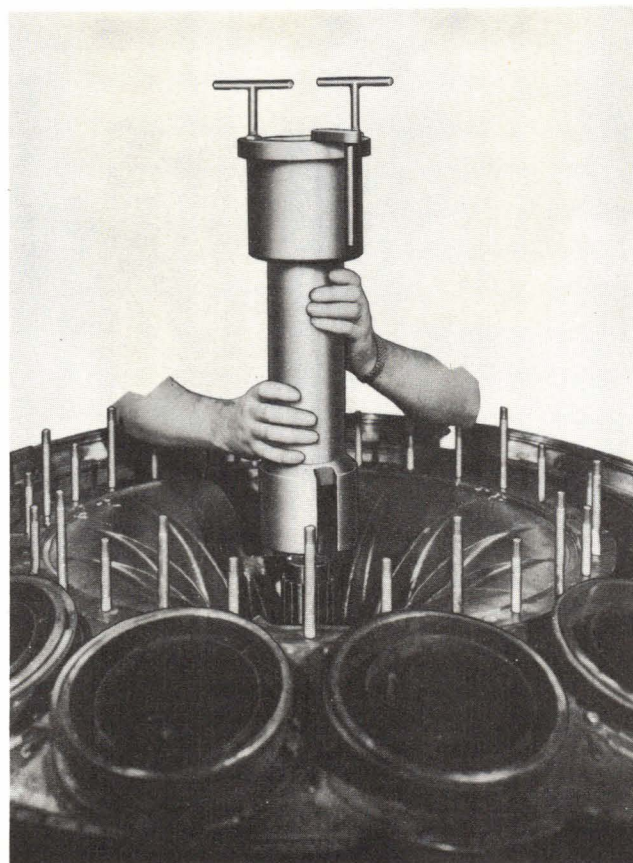
- a. Straighten the tab washer under the rear bearing retaining nut and install the wrench.

- b. Install the holder over the end of the rotor shaft so that it rests on the wrench. Loosen the nut. (See figure 5-11.)



43902

Figure 5-8. Removing the Bearing Retainer Ring with Tool No. 3615



32491

Figure 5-9. Installing Guide Sleeve No. 2963 on the Turbine Shaft

- c. Remove the holder and the wrench, and lift off the nut, washer, and spacer.

- d. Clamp the puller over the oil deflector on the shaft. Turn the handle of the puller until the deflector and the bearing are pulled loose from the shaft. (See figure 5-12.) Remove the deflector and bearing from the puller.

- e. Remove the oil seal ring from the deflector.

- f. If necessary, install the puller over the turbine shaft. Install the puller arms in the cooling vane holes and remove the cooling vanes from the shaft. (See figure 5-13.)

- g. If the turbine rotor is being replaced, lift it from the stand with the lifting eye. Attach the lifting yoke and remove the rotor to storage. (See figure 5-14.)

5-16. TURBINE DIFFUSER.

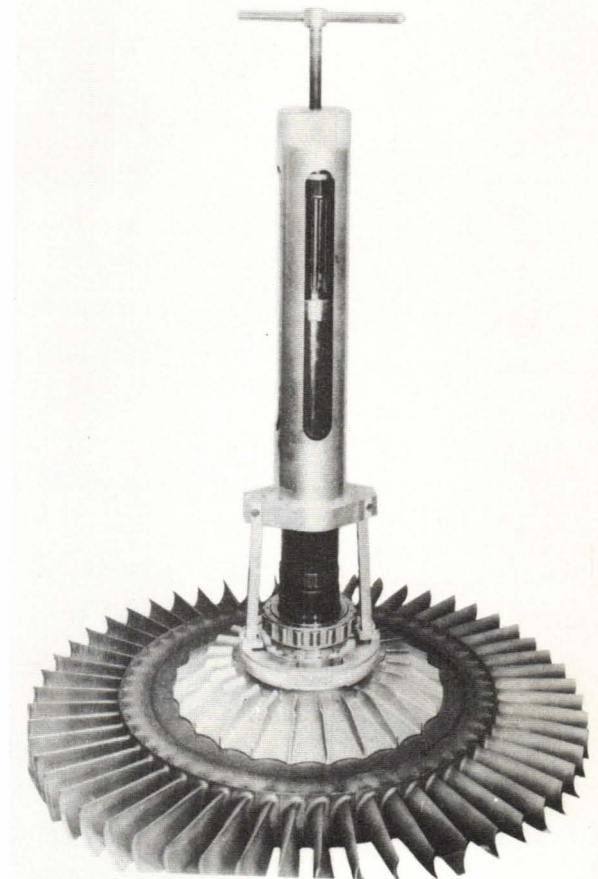
- a. Rotate the ring and tube and bearing support in the stand so that the diffuser is accessible.

- b. Cut the lockwire and remove the seven slotted engine nuts and washers which hold the diffuser to the turbine bearing support. (See figure 5-15.) Remove the diffuser, diffuser screen, and gasket. Place it on a bench with the fillister-head screws up.

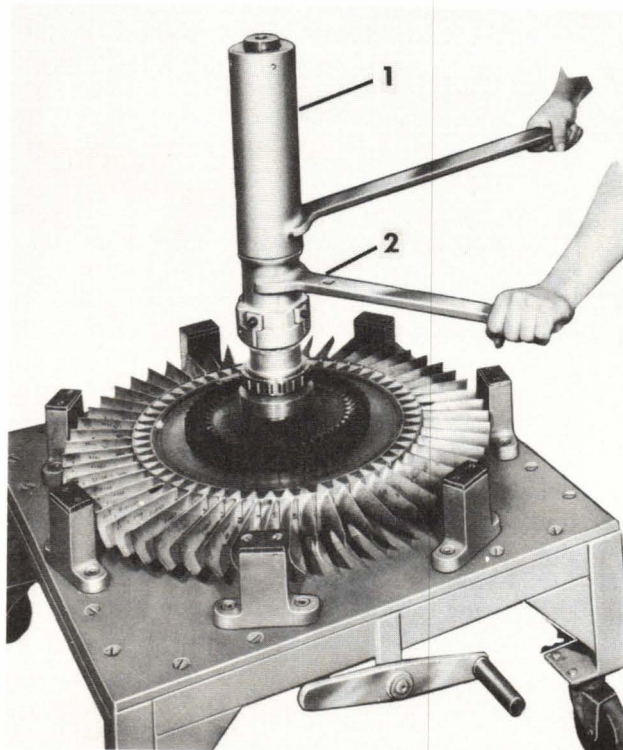
- c. Cut the lockwire and remove the six fillister-head screws which attach the oil seal to the diffuser. Remove the oil seal and discard the gasket.



43701
Figure 5-10. Removing the Turbine Unit from the Turbine Rotor with Sling No. 3631



89184
Figure 5-12. Removing the Turbine Rear Bearing and Oil Deflector with Puller No. 3653



1. Holder No. 2956 2. Wrench No. 2955
Figure 5-11. Removing the Turbine Rear Bearing Retainer Nut

5-17. RING AND TUBE.

(Tool Group No. 17.)

a. Remove the cotter pins and fourteen nuts which fasten the ring and tube to the turbine bearing support. Remove the washers and spacers from the mounting studs. (See figure 5-16.)

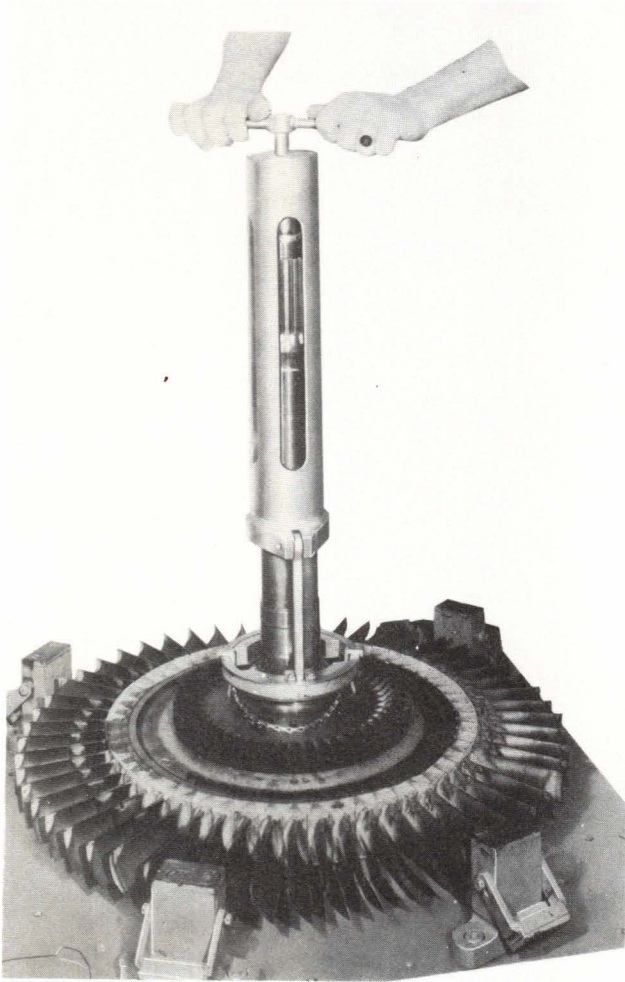
b. Attach the lifting fixture from the overhaul stand to the ring and tube. Attach the lifting yoke to the lifting fixture by inserting the pins on the ends of the yoke into the holes in the lifting fixture. Remove the ring and tube from the turbine bearings support with a hoist. (See figure 5-17.)

c. Place the ring and tube in the turbine assembly stand and fasten it. Remove the lifting yoke. (See figure 5-18.)

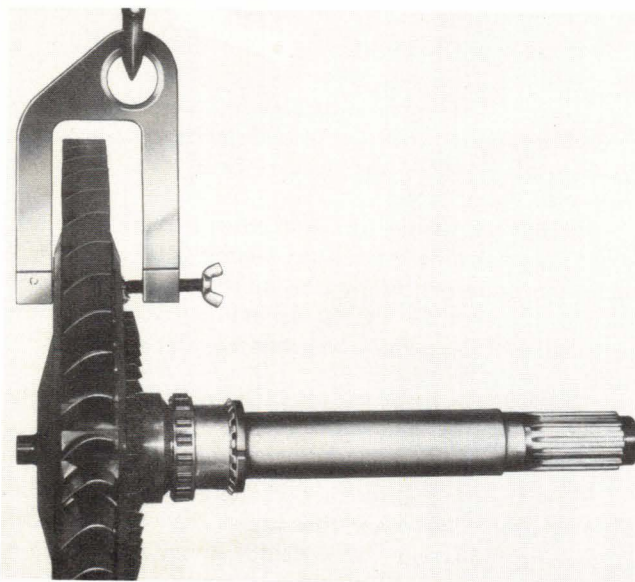
d. Cut the wire and remove the flange pad insulation.

e. Straighten the lockwasher under the 14 inner liner positioning bolts on the outside of the combustion chambers near the exhaust end and remove the bolts.

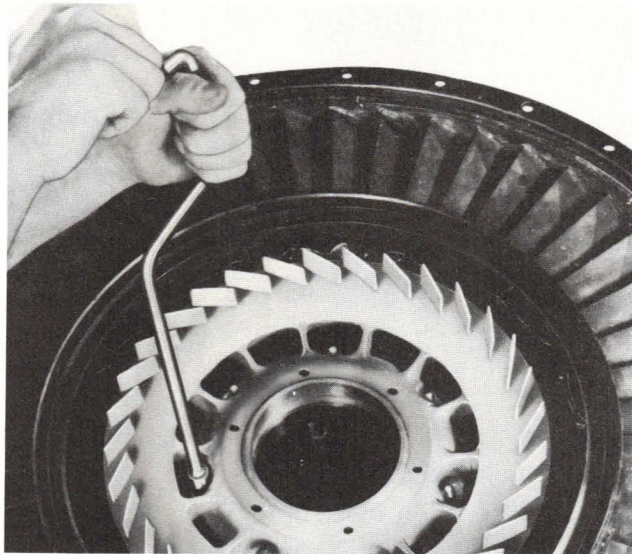
f. Rotate the ring and tube to flight position. Slide the inner crossover tubes and spacer springs out of position and remove the inner liners. (See figure 2-21.)



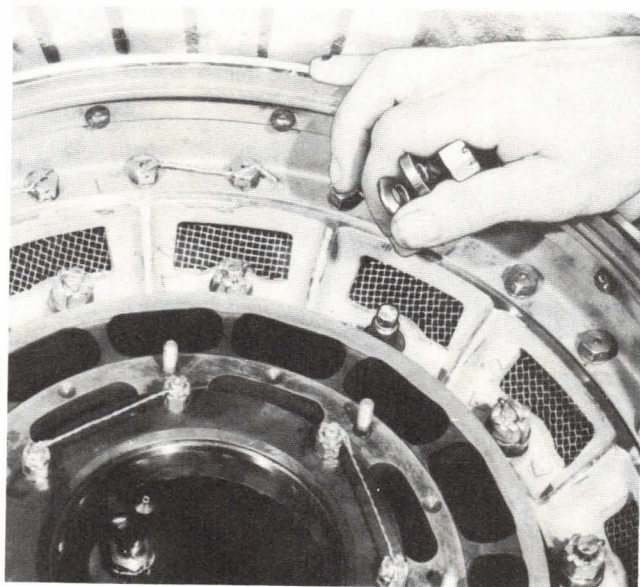
65668
Figure 5-13. Removing the Turbine Cooling Vanes with Puller No. 3653 and Arm No. 3669



32748
Figure 5-14. Lifting the Turbine Rotor with Yoke No. 2973



29880
Figure 5-15. Removing the Diffuser Retaining Nuts



45028
Figure 5-16. Removing the Ring and Tube Retainer Nuts, Washers, and Spacers

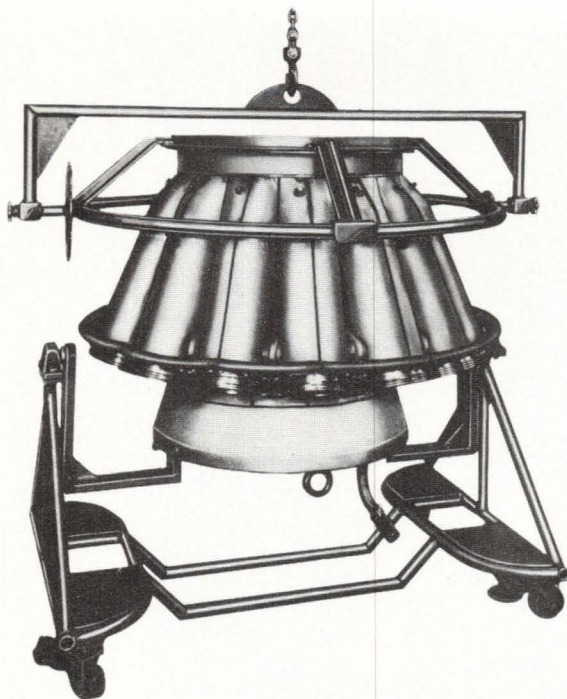
g. Remove the bolts and tie bars that secure the inner and outer air baffle sectors to their mounting flange. Remove the air baffle sectors. (See figure 5-19.)

h. Cut the lockwire and remove the bolts and washers which secure the turbine nozzle and baffle to the ring and tube. Remove the baffle and turbine nozzle. (See figure 5-20.)

5-18. TURBINE BEARING SUPPORT.

(Tool Group No. 17.)

- a. Lift off the turbine rear bearing support screen.
- b. Cut the lockwire and remove the seven slotted engine nuts which hold the bearing retainer ring. Remove the ring.

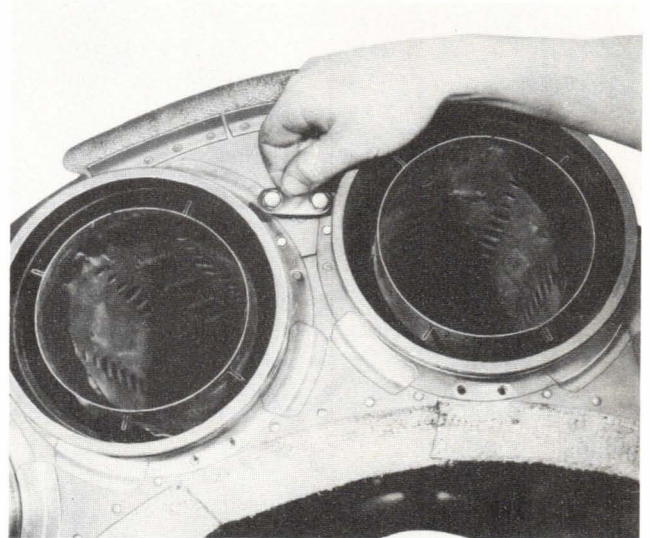


31928
Figure 5-17. Removing the Ring and Tube from the Turbine Bearing Support with Yoke No. 9074005

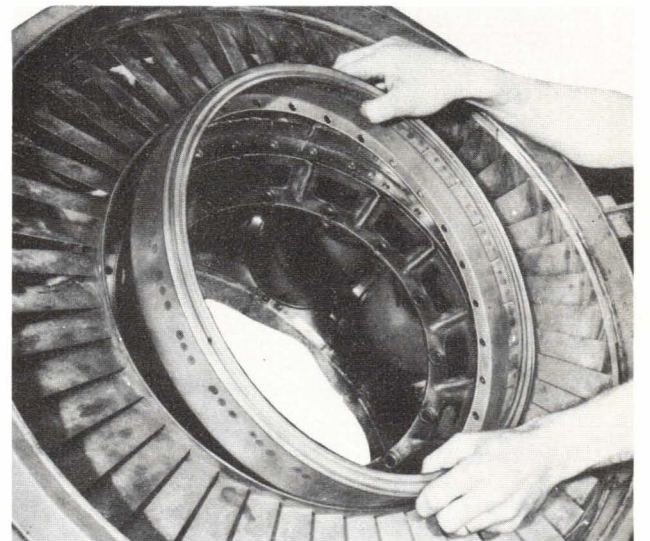


31929
 1. Mounting Ring No. 9074002-1 2. Stand No. 9074002

Figure 5-18. Ring and Tube in the Turbine Assembly Stand



39192
Figure 5-19. Removing the Air Baffle Sectors



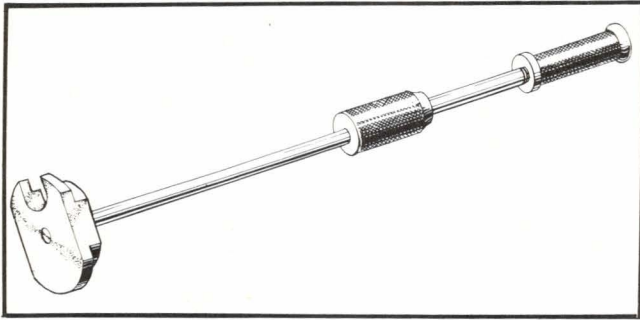
32602
Figure 5-20. Removing the Turbine Nozzle and Gas Baffle

c. Use the puller to remove the rear bearing cage and outer ring. (See figure 5-21.) Separate the bearing outer ring from the cage with an arbor press. (See figure 5-22.)

d. Cut the lockwire and remove the fillister-head screws which attach the front and rear sections of the shroud to the bearing support. Remove both sections of the shroud. (See figure 5-23.)

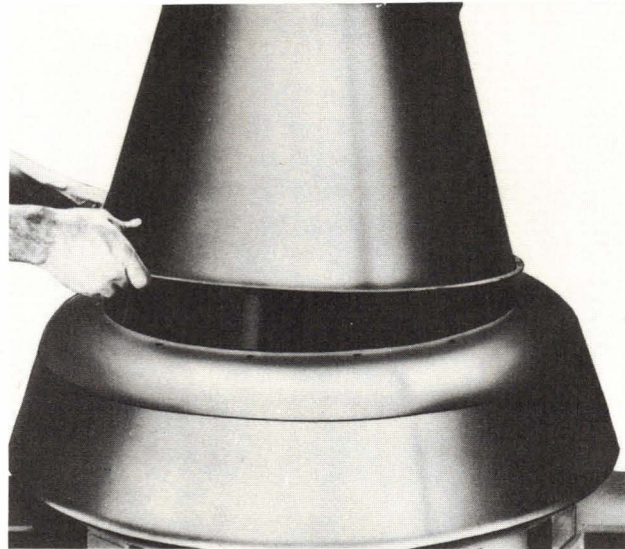
e. Loosen the coupling nuts and remove the turbine bearing pressure oil hose. Loosen the flared tube nut and remove the 90-degree oil inlet elbow. Separate the nut and gasket from the elbow and discard the gasket. Remove the union from the bearing support and discard the gasket.

f. Cut the lockwire and remove the jet and filter. Discard the gasket.



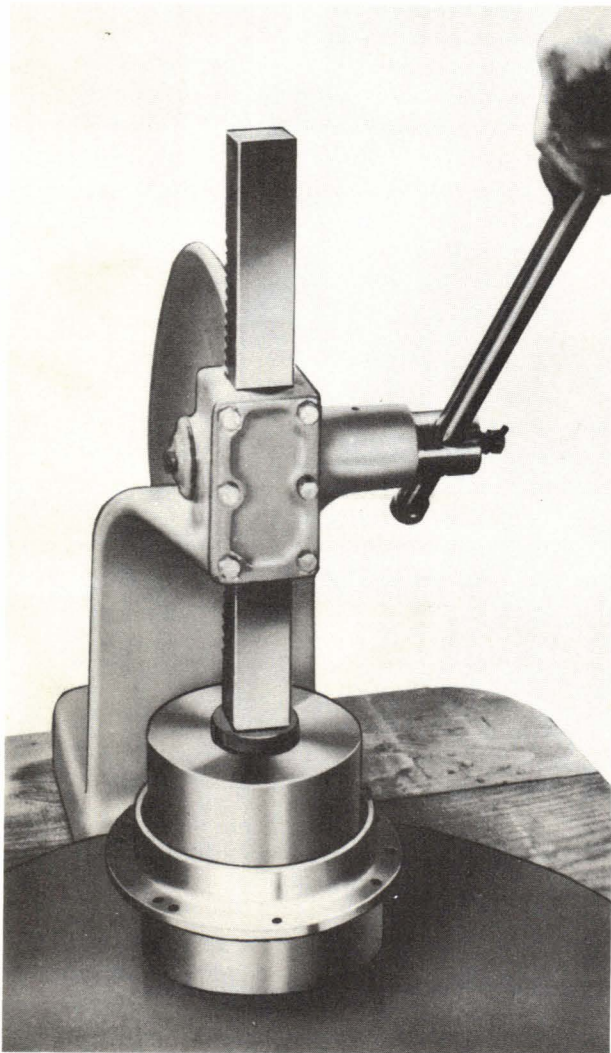
62999

Figure 5-21. Impact Puller No. 2971



29975

Figure 5-23. Removing the Turbine Bearing Support Air Shroud

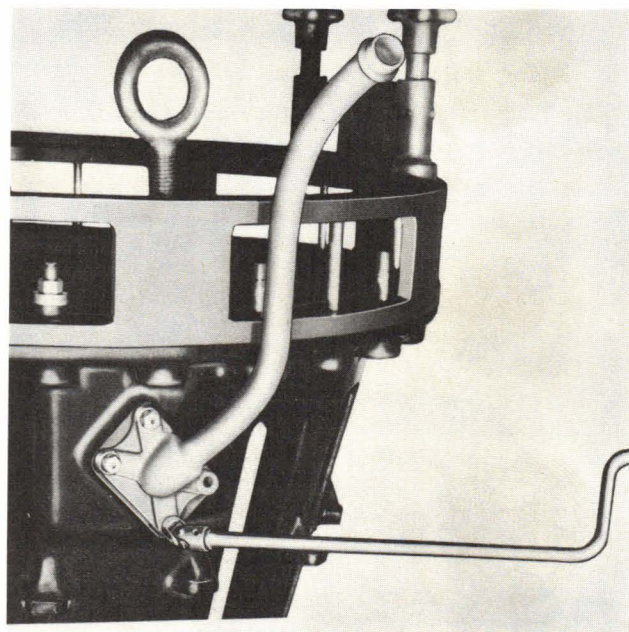


26824

Figure 5-22. Pressing the Turbine Rear Bearing Outer Ring from the Cage with an Arbor Press

g. Cut the lockwire and remove the bolts holding the scavenge tube to the bearing support. Remove the tube and discard the gasket. (See figure 5-24.)

5-19. CLEANING. (Refer to NavAer 07-1503 and 07-1504.) Be extremely careful to identify correctly the



32509

Figure 5-24. Removing the Oil Scavenge Line

metal a part is made of before cleaning it. Use the following materials to clean the parts while they are disassembled.

a. Clean steel parts with MIL-C-5546A. Rinse with water and spray with TT-T-291a. Slosh the parts in a rust-preventive made of one part MIL-C-6529, type I, and three parts MIL-O-6081, grade 1010, oil; undiluted MIL-C-6529, type III, may also be used.

b. Clean magnesium and aluminum parts with MIL-M-7752 (Aer). Rinse with water and dry with compressed air. Do not use a rust-preventive.

c. Use TT-T-291a solvent to flush passages which cannot be cleaned directly. Remove all plugs before flushing.

d. Use TT-T-291a solvent to flush oil nozzles and filters. Use it also to flush the oil passages of the turbine bearing support; dry the passages with compressed air.

e. Use either TT-T-291a or TT-N-97 to clean bearing cages and bores.

f. When ball or roller bearings are removed, clean them with TT-T-291a or TT-N-97. Use dry compressed air to remove foreign material; do not allow the bearings to spin in the air blast because high speed will damage them.

g. The cleaning solvent recommended for non-ferrous parts is P-S-661 or equivalent. Clean steel parts with a water solution. All parts may be cleaned with a cold dip.

h. Clean hot section components in MIL-C-7754 (Aer) so that they may be inspected.

5-20. INSPECTION AND REPAIR.

5-21. The following paragraphs describe the repair which may be done by Class C maintenance. This repair is done only to increase flight safety and to increase the time a part may be used; if a part was performing satisfactorily before Class C maintenance disassembly, it is likely that it will continue to operate safely until the next overhaul. Consider this when deciding the amount of repair an engine requires.

5-22. WELDING.

a. Use inert gas and a MIL-R-5031, composition 6, weld rod to weld the exhaust section, turbine nozzle, ring and tube, and burner domes. Metallic arc welding with a MIL-E-6844, composition 6 or 9, rod is an alternate for these parts.

b. Use inert gas and a MIL-R-5031, composition 8A, weld rod to weld the inner liners and solid turbine nozzle vanes.

c. Replace a part instead of repairing it if the cost of repairing it seems more than the part is worth.

d. Do not distort parts while repairing them. Measure each part after welding to make sure that the critical dimensions are within limits.

5-23. EXHAUST CONE.

(Tool Group No. 6.)

a. Repair broken welds in any part of the outer exhaust cone. Weld minor cracks or breaks with heli-arc method. The weld must fill the cracks and overlap the adjacent metal $\frac{1}{4}$ inch.

b. Cracks adjacent to the strut attaching welds are permissible up to $\frac{1}{2}$ inch long. Cracks one inch long are permitted in strut walls.

c. Cracks in attaching flange bolt holes that extend into the outer diameter are permissible provided no more than half the holes are cracked. Weld cracks from the mounting flange holes to the formed flange radius and blend to the original contour and flange thickness.

d. Remove distortion of either the inner or outer exhaust cone provided the re-forming does not result in

creasing and provided the metal can be returned to within $\frac{1}{8}$ inch of its original contour.

e. Remove the inner cone to replace parts if the inner cone is excessively loose because of support dowel tube wear or if the inner cone is damaged beyond repair.

f. Use the gauge to check the relationship between the front face of the outer cone mounting flange and the leading edge of the inner cone. (See figure 5-25.) If the clearance on the inner cone is not correct, build the cone to the proper height by welding. In addition, check the clearance of the inner cone outer diameter and the inner diameter of the outer cone. These two clearances must be within the limits given in paragraph 5-119. If the limits are not met, disassemble the cone and replace the defective parts.

g. If the clearance between the outer diameter of the inner cone surface and the support strut spacer clips is not within limits given in paragraph 5-119 and if no part defect is obvious, adjust the clearance.

h. Center the inner cone relative to the outer cone mounting flange bolt circle as nearly as possible.

i. Grind away the clip attaching welds and relocate the clip to obtain a total diametrical clearance within limits. Reweld the clip in place. Use a new clip if the old one is damaged beyond use.

j. Weld the thermocouple boss locating shoulder if it is cracked. If a locating shoulder is missing, replace the thermocouple boss.

5-24. TURBINE SHROUD.

5-25. Inspect for cracks in the outside wall of the four countersunk alignment holes. Repair cracks in the outside wall of the four countersunk alignment holes by filling the crack with weld material. Grind away excess weld material in the bolt hole to provide clearance for the bolt head.

5-26. TURBINE BLADES.

5-27. No limit has been set for the length of time that turbine blades may be used. Continue blades in service as long as they meet the requirements in paragraph 2-139.

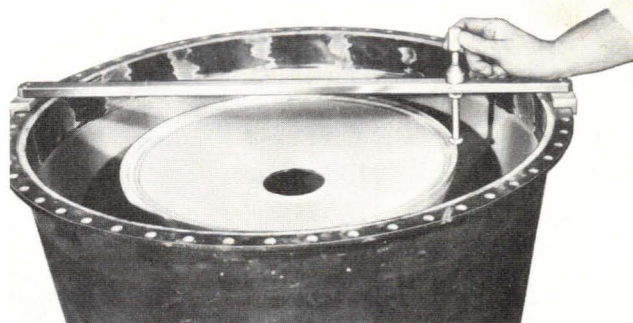


Figure 5-25. Checking Inner Exhaust Cone Position with Gage No. 2988

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5-28. TURBINE BLADE REMOVAL.

(Tool Group No. 11.)

a. Remove the exhaust cone and one-piece shroud. (Refer to paragraph 2-154.)

b. Insert a piece of stencil paper between the rear face of the gas baffle and the forward side of the blade to be removed.

c. Use a hammer and a drift made of unhardened steel, shaped to avoid damage to wheel slots, to drive the blade forward to shear the pin. Forward movement of approximately $\frac{3}{32}$ inch is enough to shear the blade locking pin. Control the forward movement of the blade by using light taps of the hammer to avoid damaging the gas baffle.

CAUTION

Do not attempt to shear the blade locking pin with the puller.

d. After shearing the blade pin, use the puller (see figure 2-34) to withdraw the blade from the serrated slot of the turbine wheel.

e. If the turbine wheel has been removed from the engine, remove the blades by driving them forward with the drift.

f. Rotate the turbine wheel in the direction of rotation and inspect the gas baffle through the vacant wheel broach in the turbine wheel to be sure that the gas baffle is not damaged.

g. Drive the sheared pin from the wheel with a drift with a one-inch long straight shank of 0.112 inch diameter or the drift from the tool group. (See figure 2-35.) Drive the pin from the fillet of the wheel toward the serrations. Protect the wheel face with a metal shield.

Note

If the pin sticks in the pin hole, apply a small quantity of penetrating oil. (Refer to paragraph 2-30.) Let it stand for two hours.

h. Remove the turbine blade 180° from the removed blade, even if it is not damaged. Remove its locking pin. Remove only one pair of blades at a time and make certain they are diametrically opposite.

i. When the blades have been removed, inspect the wheel for cracks. (Refer to paragraph 5-37.)

5-29. TURBINE BLADE INSTALLATION.

(Tool Group No. 10.)

5-30. Gauge the locking pin holes with the plug gauges to determine whether a standard or oversize locking pin will be required. (See figure 2-36.)

a. Insert the *Go* end of the smallest gauge in the serration end of the pin hole. If the hole is not damaged, and

the *No-go* end of the gauge will not slip into the hole, use a standard-size pin. If the *No-go* end of the standard-size gauge will fit into the hole, try successively larger gauges until a gauge is found which will enter the hole on the *Go* end but will not enter the hole on the *No-go* end.

CAUTION

If the *Go* end of the gauge will enter the pin hole at the serration end but binds at the wheel-fillet end of the hole, do not try to force the gauge through the wheel fillet end of the hole. Select a tapered reamer of the same maximum diameter as the *Go* end of the gauge. (See figure 2-37.) Insert the reamer through the serration end of the hole and ream the fillet end of the hole. Use a reamer pilot fixture to guide the reamer. Mark the wheel near the hole to indicate which size pin should be installed.

b. If the pin hole is damaged, gauge the hole to determine its maximum diameter. Select a tapered reamer of the proper size and ream the hole to the next oversize pin diameter.

5-31. Before installing blades and locking pins, check the axial location of the blade in the wheel broach and check that the blade will move in the serration with thumb pressure. Make this check before pinning blades to avoid shearing a new pin and reprocessing the pin hole when a blade fails to meet the axial position limits. Use the gauges for this check.

a. Insert the proper size gauge in the pin hole with the blade in position, and make sure the step end of the gauge enters and bottoms in the pin slot of the turbine blade. Determine this by feel. Do not hammer the gauge into position.

b. Use the axial location gauge to measure the axial location of the rear end of the serrated base of the blade with relation to the rear face of the turbine wheel flange. (See figure 2-38.) This measurement must be +0.025—0.010 inch. If the tool is not available, measure the position of the rear side of the blade base relative to the turbine wheel aft flange.

c. If the rear face of the turbine blade base does not position within the 0.025-0.010 inch limit, switch the positions of the matched pair of blades to see if the mated blade will fall within the limits. If not, install another pair of mated blades which will position within these limits.

d. When the mated pair of blades has been positioned within the axial limits, remove the gauges from the pin holes and check the circumferential shake of the newly-installed blades. The shake must be 0.020-0.080 inch, measured at the blade tip.

e. Choose the proper size blade locking pins. The blade pins are color coded:

Size	Color
Standard	Natural
0.010 inch oversize	Blue
0.020 inch oversize	Green
0.030 inch oversize	Orange
0.040 inch oversize	Black
0.050 inch oversize	Purple

Note

Use solid locking pins for 0.030 and 0.040 inch oversize holes.

5-32. After the pin hole at the replacement blade location is ready for installation of the pin, the axial location has been determined to be satisfactory using proper gauge and all burrs have been stoned from the vacant wheel serrations, install the mated pair of replacement blades in diametrically opposite locations.

Note

Install the heavier blade of the pair in the same location as the heavier removed blade.

5-33. INSTALLING SOLID LOCKING PINS.

- Install a locking pin of the proper size in the lockpin hole with the elongated swaged section of the pin in line with the direction of rotation. Be sure that the end of the pin will enter the slot in the blade base.
- Using a drift with a 0.112-inch diameter straight shank one inch long or the drift from the tool group, carefully tap the pin through the wheel hole into the blade slot until the blade begins to tighten in the wheel. (See figure 2-35.) The pin will be in its proper position when the inner end is barely bottomed in the blade slot and the outer end is completely entered into the wheel hole. The pin should not be tapped again.

CAUTION

The locking pin will bend forward during installation if it is tapped after it has bottomed in the blade slot. This bending will cause the blade to move forward so that the $+0.025$ — 0.010 inch axial blade position limit with the rear face of the wheel cannot be met.

- Tap each replaced blade on the platform at the rear of the blade base with a plastic or fiber drift to make sure that the blade is not binding on the pin and that it is free for circumferential shake.
- If the wheel has been ground for balance at the pin hole, the pin will extend slightly. Do not cut it off because it then would not balance with the pin of the mating blade.

5-34. The leading and trailing edge of the replacement blades when installed may be different from the other blades in the turbine wheel. Disregard this difference because the replacement turbine blades may have been mixed with other pinned blades.

5-35. After the exhaust cone shroud has been re-installed, measure the blade tip-to-shroud clearance of each replaced blade to be sure that it is within limits in paragraph 5-119.

5-36. INSTALLING EXPANSION LOCKING PINS. Use the solid-pin procedure with these exceptions:

- Gauge the pin holes and temporarily mark oversize holes.
- Place pins in the holes with the pin slot in the direction of rotation.
- Tap the pin for an oversize hole into a 0.124-0.126 inch diameter hole $\frac{1}{4}$ inch deep in a steel block.
- Drive a thin-wedged tool into the pin slot. Spread the pin so that the diameter measured 90° from the slot is 0.008-0.012 inch larger than the oversize hole diameter.
- Pin matched pairs of blades with the same type pin.

5-37. TURBINE WHEEL.

5-38. Inspect the turbine wheel and shaft for damage.

- Scoring of the wheel and blades is allowed if the grooves are not more than $\frac{1}{8}$ inch deep. If the grooves are $\frac{1}{8}$ - $\frac{3}{16}$ inch deep, replace all the turbine blades. If the scoring is deeper than $\frac{3}{16}$ inch, replace the turbine wheel.

- If more than 10 blades are bent over $\frac{1}{4}$ inch or more from their normal positions, replace the turbine wheel.

5-39. Inspect the turbine wheel for cracks. When the turbine blades are removed from wheel for any reason, visually inspect the blade slot for cracks emanating from, or forward of, the blade pin hole. Reject the turbine wheel if a crack is found extending either forward or rearward from the pin hole longer than $\frac{1}{2}$ inch or within $\frac{1}{4}$ inch of either the pin hole or the front face of the wheel.

5-40. TURBINE DIFFUSER.

5-41. Inspect the turbine diffuser for damage:

- Remove minor nicks and dents by blending.
- Replace the diffuser if it is excessively damaged.

5-42. TURBINE NOZZLE WITH HOLLOW VANES.

5-43. Inspect the nozzle for distortion, cracked welds, cracked vane rings, and damaged vanes. Inspect the nozzle inner mounting flange in the area forward of the retaining pin welds with dye penetrant. (Refer to paragraph 2-29.) Replace the nozzle if the flange cracks pass through the weld area in front of more than four retaining pins. Return the turbine nozzle to overhaul for replacement of the flange. A new replacement nozzle must have the area as near as possible to that of the

replaced nozzle, minimizing the effect on thrust and exhaust gas temperature.

Note

These turbine nozzle inspection and repair limits apply to nozzles removed from the engine during class C maintenance. When the turbine rotor and nozzle is not removed, the nozzle must meet the requirements in paragraph 2-127.

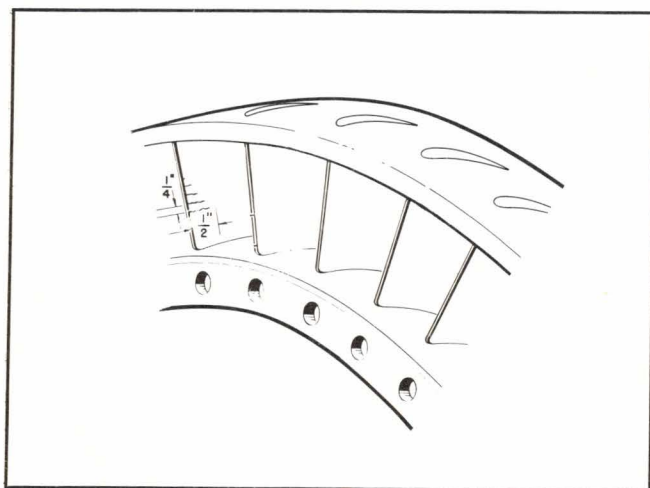
CAUTION

Excessive shrinking of the turbine nozzle inner spacer ring will result in overheating of the turbine wheel and blades in the dovetail area during engine operation. Replace and scrap any nozzle with a minimum outer diameter of the inner spacer ring of less than 17.830 inches.

5-44. If the limits shown in figure 5-26 are not exceeded, the nozzle will be satisfactory for continued service without weld repair.

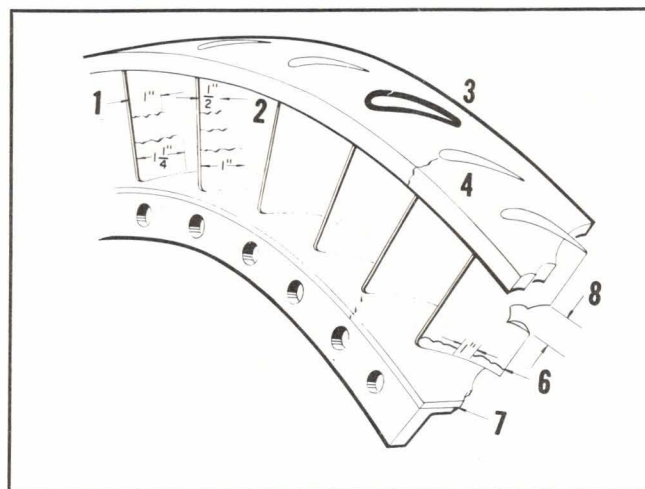
5-45. Remove turbine nozzle and repair by welding if cracks exceed the limits shown in figure 5-26, provided they do not exceed the limits shown in figure 5-27.

5-46. Nozzles with damage exceeding the limits shown in figure 5-27 will be condemned and tagged for disposition as administratively-condemned property.



Condition	Number Allowable	Separation Limit	Convergence Limit
Vane cracks less than 1/2 inch long	Any number	1/4 inch	1/4 inch
Nicks or dents less than 1/2 inch	No limit		
Distortion or warping of vane trailing edge less than 3/16 inch	No limit to size or number of vanes affected		

Figure 5-26. Inspection Limits for Turbine Nozzles Not Requiring Repair



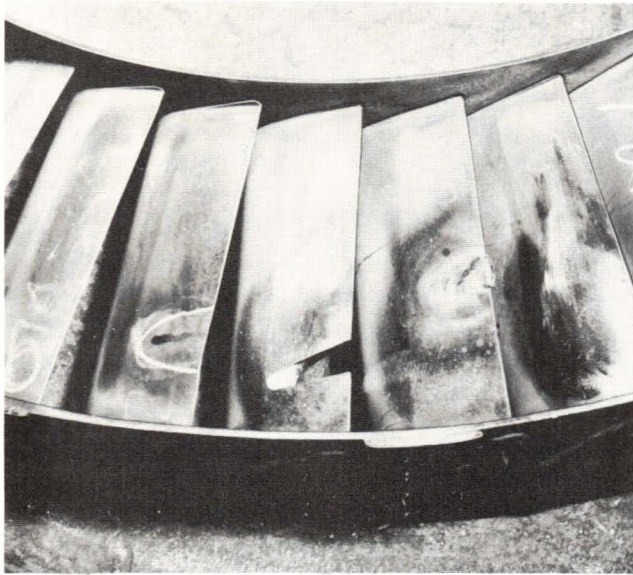
Number	Repair Procedure
Allowable	
1. Vane cracks 1 inch to 1 1/2 inches long	3 per vane Notch crack with hand grinder or file, weld and blend out
2. Vane cracks 1/2 inch to 1 inch long	5 per vane Notch crack with hand grinder or file, weld and blend out
3. Cracks in weld securing vane to spacer ring	Any number Notch crack with hand grinder or file, weld and blend out
4. Crack in inner or outer spacer band	Any number Notch crack with hand grinder or file, weld and blend out
5. Nick or dent greater than 1/16 inch deep	Any number Fill with weld material and blend out if the nozzle is being repaired for other reasons
6. Cracks from leading and trailing edges converging to within one inch	1 per vane Grind out cracks, fill with weld material, and blend with vane
7. Mounting flange cracks	(Refer to paragraph 5-48.)
8. Metal broken from vane trailing edge	One square inch maximum total area Clean up edges with grinder, fill with weld material, and blend with vane

Figure 5-27. Inspection Limits for Repairable Turbine Nozzles

5-47. Refer to figure 5-28 for weld repair of a cracked vane.

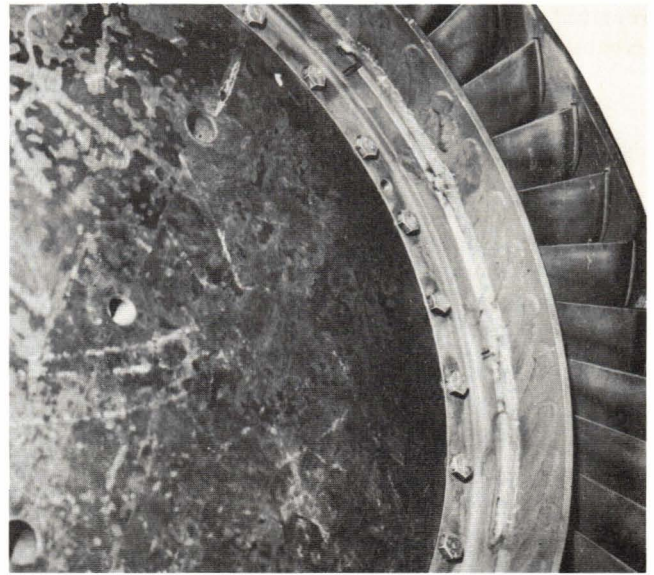
5-48. Refer to figure 5-29 for weld repair of a cracked mounting flange weld. Grind out the crack with a V-dressed grinder to a depth at least one-half of the flange material. If the crack is in the aft weld, grind out the old weld material covering the crack. Fill the V with specified filler material. Excess weld material buildup is permissible provided it does not extend above the pin weld material. Remove the weld only as necessary to meet this requirement. The flange must be bolted to a fixture during this weld repair to prevent distortion. Tack-weld cracks before completing the final weld.

5-49. See figure 5-30 for dimensional inspection limits. Replace the nozzle if it cannot be reworked to within the specified limits.



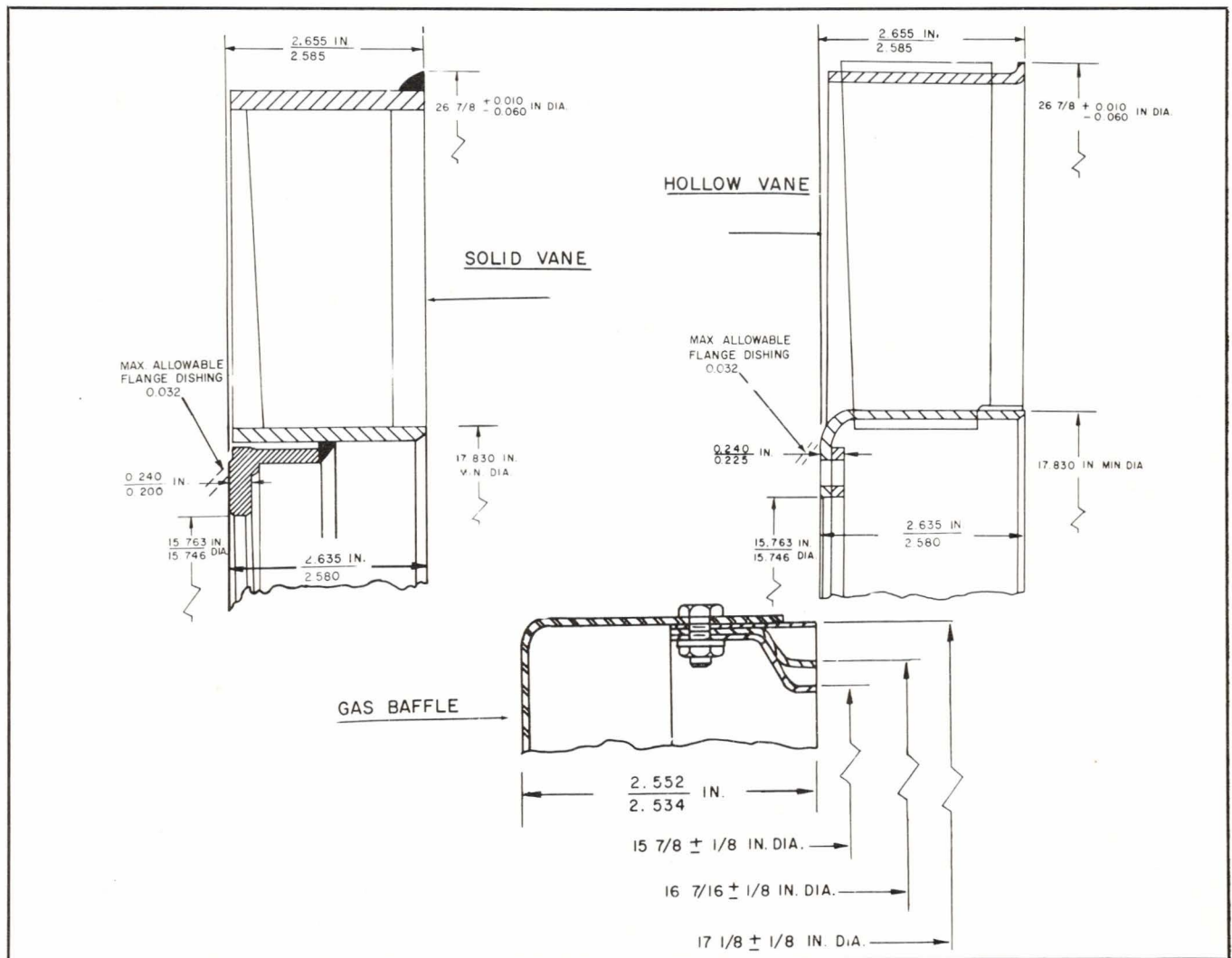
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Figure 5-28. Weld Repair of Cracked Turbine Nozzle Vanes



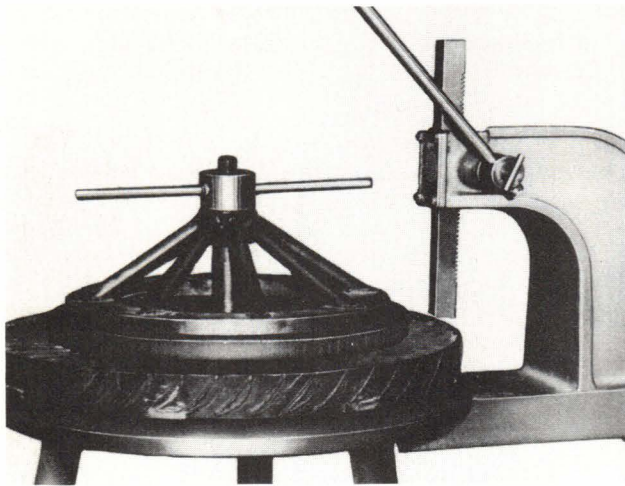
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Figure 5-29. Weld Repair of Cracked Turbine Nozzle Mounting Flange Weld



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Figure 5-30. Turbine Nozzle and Gas Baffle Inspection Limits



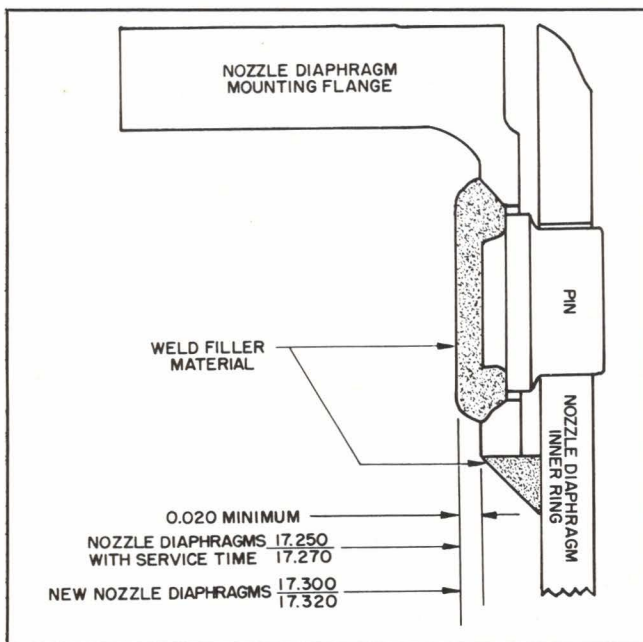
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Figure 5-31. Aligning the Turbine Nozzle Outer Ring with a Locally-fabricated Fixture in an Arbor Press

5-50. Correct turbine nozzle outer ring distortion by using an arbor press and special fixture shown in figure 5-31.

5-51. Straighten tilted inner ring-to-mounting flange lip retaining pins by applying pressure to the inner ring and drifting the pin back into its original position. Replace the nozzle if it will not meet the pin weld diametrical limits (see figure 5-32) while each pin is secured with puddled weld metal of a thickness not less than 0.020 inch.

5-52. Build up the weld at each pin by puddling over the old weld and adding enough weld material to build up the weld to a $\frac{1}{32}$ -inch thickness measured from the inner surface of the mounting flange lip.



72226

Figure 5-32. Turbine Nozzle Mounting Flange Retaining Pin Welding

5-53. Grind down the weld material at the inner ends of the pins to bring the assembly within the between pin weld diametrical limits, but do not grind the weld material of any one pin to a thickness of less than 0.020 inch measured from the face of the mounting flange lip. (See figure 5-32.)

5-54. TURBINE NOZZLE WITH SOLID VANES.

5-55. The solid vane nozzle has been superseded by a nozzle with hollow vanes and a one-piece inner-ring.

5-56. Inspection, rework, and repair is the same as that for the new nozzle with these exceptions.

a. Distortion of the trailing edge of vanes less than $\frac{1}{8}$ inch is permissible.

b. Ballooning the vanes less than $\frac{1}{16}$ inch is permissible.

c. Any number of nicks or gouges less than $\frac{1}{32}$ inch deep is permissible within $\frac{1}{8}$ inch of the trailing edge of a vane, provided rough edges and burrs are removed.

d. Repair cracks less than $\frac{1}{8}$ inch long, dents, or nicks in the trailing edge of the vane by grinding the trailing edge as required. Do not exceed $\frac{1}{8}$ inch. The finished profile must have a minimum width of $\frac{1}{2}$ inch and maximum width of one inch. Two reworked areas of $\frac{1}{2}$ inch on the trailing edge of each vane with a maximum of 25 vanes per nozzle are acceptable.

Note

Disregard cracks in the trailing edge less than $\frac{1}{8}$ inch long after testing after minor repair.

e. If the blade damage exceeds the limits, replace the turbine nozzle.

5-57. TURBINE SHAFT BEARINGS.

5-58. Refer to NavAer Publication Letter No. 10420.1 and NavAer 01-1A-503 for inspection and preparation of new bearings for installation.

5-59. COMBUSTION CHAMBER INNER LINERS.

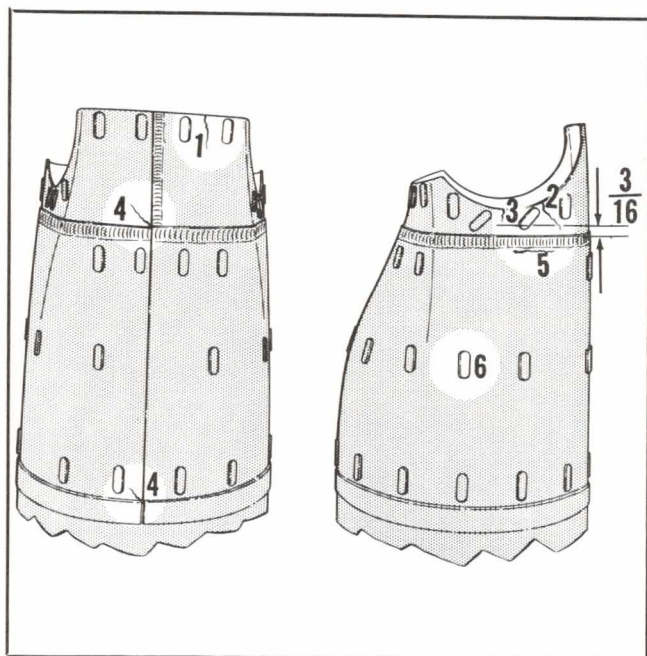
5-60. Carefully inspect the liners and repair or replace them in accordance with the following limits:

a. Replace the liner if it is badly burned, severely buckled, or if any pieces are broken out.

b. Replace the liner if buckling cannot be straightened to within $\frac{1}{8}$ inch from normal contour of liner without creasing the metal.

c. Replace the liner if more than 15 crack weld repairs are required.

d. Replace the liner if cracks in transition section exceed the following length limits. (See figure 5-33.) Weld cracks from the rear end forward less than one inch long, at least $\frac{3}{16}$ inch from the seam weld. Weld cracks starting at the point of seam weld intersection on the top and bottom extending outward up to $\frac{3}{4}$ inch long. Weld any crack up to $\frac{3}{4}$ inch long parallel to and adjacent to the seam welds.



Condition	Limits	Disposition
1. Crack at rear lip	Over one inch long	Reject liner
	Less than one inch long	Repair by welding
2. Crack	Extending to within $\frac{3}{16}$ inch of seam weld or over one inch long	Reject liner
3. Crack	Less than one inch long and not within $\frac{3}{16}$ inch of seam weld	Repair by welding
4. Crack from seam weld junction	Over $\frac{3}{4}$ inch long	Reject liner
	Less than $\frac{3}{4}$ inch long	Repair by welding
5. Crack adjacent to and parallel to seam weld	Over $\frac{3}{4}$ inch long	Reject liner
	Less than $\frac{3}{4}$ inch long	Repair by welding
6. Worn spacer pad	Over 0.035 inch thick	Acceptable
	Less than 0.035 inch thick	Build up with weld thick

Figure 5-33. Inner Liner Transition Section Inspection and Repair Limits

e. Replace the liner if there is rubbing or pick-up area in excess of $\frac{1}{8}$ inch diameter found between the spacer pads at the transition end of the liner caused by torquing the outer combustion chamber. Remove any metal pick-up or spikes less than $\frac{1}{8}$ inch diameter found on otherwise acceptable liners.

5-61. If it is otherwise acceptable, weld the liner if it is cracked in the transition section or if there are cracks over $\frac{1}{4}$ inch long in the body section of the liner. Cracks less than $\frac{1}{4}$ inch long in liner body need not be welded unless there is danger of metal breaking out. Refer to paragraph 5-22 for weld procedure. The weld bead must not be thicker than the thickness of the liner material.

Note

After welding in the vicinity of louvers, inspect for proper louver opening of 0.062 ± 0.010 inch; reset if necessary.

5-62. If spacers or locating pads on the transition end of a liner are worn thinner than 0.035 inch, rebuild them with weld material. Grind to original shape and a thickness of $\frac{1}{16}$ inch.

5-63. If the inner liner locating dowel bolt hole is elongated or otherwise damaged, close the hole by welding and redrill it. (Refer to paragraph 5-22.)

5-64. RING AND TUBE.

5-65. Reweld any broken seams. Repair ruptured seams and tears by welding on a patch of like material of sufficient size to cover the damaged area. An expanding back-up is necessary to prevent warping during welding. Preheat the area of the web section immediately before welding. Make the weld internally and hold the bead height to a minimum consistent with satisfactory weld strength.

5-66. Internal pitting resulting from liner rub is acceptable provided the wear does not exceed 50 percent of the wall thickness. Fill depressions caused by excessive wear with welding material. Grind weld protrusions to the original wall thickness.

5-67. Straighten any outer tube flanged faces that are not flat.

5-68. Remove all dents and distortions from the combustion chamber outer tubes.

5-69. Place the ring and tube unit on a fixture and true up the exhaust cone mounting flange by bumping it with a rawhide mallet so that it is concentric within 0.020 inch total indicator reading.

5-70. Repair damaged turbine nozzle mounting flange bolt holes by removing the damaged area in sufficient circumference to permit installation of a stainless steel bushing. Secure the bushing by installing a lockpin.

5-71. Repair damaged lifting eye bosses and liner lock-screw bosses by removing the damaged boss and welding on a boss taken from a condemned ring and tube unit if new bosses are not available in supply.

5-72. Repair minor damages in the area next to the rear mounting flange:

a. Repair cracks by puddling the weld material over the crack and grinding the weld area smooth.

b. Repair blistered areas or areas containing burned holes. Cut out the damaged area with a torch. Smooth the edges of the hole. Use a piece of rolled stainless steel, AMS-5646, for making and forming a rectangular patch to fit over the affected area. Clamp the patch in place on the outside surface of the flange tube and fillet-weld it in place.

c. An area less than one inch in diameter which has distortion less than $\frac{1}{16}$ inch need not be repaired, provided the inner surface metal is not burned or a crack has not originated in the distorted area.

5-73. Inspect the ring and transition gusset plates from the rear of the ring and tube.

- a. Repair any cracks in the gusset plates or their attaching welds.
- b. Repair all cracks in the ring and tube by heli-arc or metallic arc method. (Refer to paragraph 5-22.)

5-74. TURBINE BEARING SUPPORT.

5-75. Repair of the turbine bearing support is limited to replacement of serviceable components.

- a. Replace loose or damaged studs. Use a small amount of JAN-A-669 lubricant on the stud threads before installation.

- b. Condemn turbine bearing support if it cannot be reworked to correct damaged casting, excessive galling, or bore misalignment.

- c. Small cracks in the outer wall of the cooling air openings at the rear of the bearing support are acceptable if such cracks can be removed entirely by blending out to a maximum radial depth of $\frac{1}{8}$ inch and a maximum length of $\frac{1}{2}$ inch forward. If cracks exceed these limits replace the bearing support.

5-76. TURBINE COUPLING.

5-77. Inspect the turbine to compressor coupling:

- a. Clean burrs, galling, or rust from the splines with crocus cloth.
- b. Replace the coupling if the splines are badly worn or damaged.

5-78. AIR ADAPTERS.

5-79. Tapped $\frac{1}{4}$ -20 holes at the instrumentation boss of the air adapter with stripped or damaged thread can be repaired with Heli-coil inserts, part number 1185CN x $\frac{3}{8}$ (MS122121). Follow the instructions provided by the Heli-coil Corporation, Danbury, Connecticut, when using the inserts. Replace damaged studs or screw bushings.

5-80. Make these repairs to the air adapter:

- a. If the lower ring boss of the fuel filter has broken off and remains in the air adapter during disassembly, remove it. Use a tool to fit under the boss and pry it loose.
- b. Use a fine grade of abrasive cloth to remove burrs from the mounting face of each adapter.
- c. With a fine stone remove any burrs and roughness from the sleeve at the large end of the adapter.
- d. If the steel sleeve has loosened and shifted in the adapter bore, reposition the sleeve and replace the retaining rivets or set screws.
- e. Replace any fitting on which the threads are damaged.
- f. If the dome supports are cracked or broken off, replace the dome.

5-81. TURBINE NOZZLE GAS BAFFLE.

5-82. Examine the three lips of the baffle for wear, crimping, or cracks. Check the tack welds on the nuts for security.

- a. Weld axial cracks extending forward from the baffle lip retaining rivets, provided they do not extend into the mounting flange radius. A maximum of six welds or replacements of six rivets is permissible. Circumferential cracks are not permitted.

- b. Cracks from relief slots in the inner baffle ring are acceptable if such cracks do not extend into the first radius of the ring.

- c. When straightening of the baffle lips is necessary, a slight distortion in the rear edge of the baffle lips is acceptable if all points on the rear edge of the lips are within the tolerance of 2.534-2.552 inch from the mounting flange face of the baffle. Grinding or machining of the lips to correct any irregularity of the edges is permissible provided the touch-up does not reduce the dimensions from the mounting flange face to the lips below the minimum inner dimension of 2.534 inch. Replacement of individual baffle lips is not permissible.

5-83. ACCESSORIES CASE.

5-84. If the oil drain plug bushing at bottom of the accessories drive case is damaged or if there is excessive oil leaking around the bushing, replace the bushing in the following manner:

- a. Drill out the two locking pins to below the bushing flange.
- b. Remove the drain plug bushing with a $\frac{3}{4}$ inch E-Z-Out.
- c. Apply Permatex No. 2 to the external threads and the underside of flange on a new bushing.
- d. Install the new bushing in the case and tighten to 60-80 pound-feet, using a locally-fabricated tool.
- e. Drill two 0.0935 ± 0.001 inch holes $1\frac{3}{32}$ inch deep in the casing at the bushing pin hole locations. Select locking pins for a drive fit. Install pins and secure by staking over the bushing metal slightly.

Note

Do not attempt to drill the pin holes if the bushing pin holes overlap the old pin holes in the case. Instead, remove the bushing and install another new bushing which will meet the requirements.

5-85. ASSEMBLY OF DISSASSEMBLED COMPONENTS.

5-86. Follow the general instructions in paragraphs 2-6 through 2-10, in paragraphs 2-24 through 2-37, and in paragraph 5-5. In addition, follow these general instructions:

- a. Refer to paragraph 2-64 for general torque limits; special limits are listed under assembly of the component. If no torque is given, screw all bolts into castings fingertight plus one-quarter turn.

- b. If extreme force is necessary to put two parts together, check the parts for burrs and pickups.

- c. Finish each step before progressing with the work.

- d. For lubricants and sealing compounds, refer to paragraphs 2-30 and 2-31.

5-87. TURBINE ROTOR. (Tool Group No. 15.)

a. Install the rotor and shaft in the stand so that the rotor rests on the support blocks. (See figure 5-34.)

b. If the cooling vanes were removed, install them over the rotor shaft. Apply MIL-L-6082, grade 1100, before installing. Make sure that the two pins in the vanes are fitted into the slots on the wheel.

c. Install oil deflector.

d. Apply VV-P-236 lubricant, and install the rear bearing inner ring and rollers on the shaft. Heat the bearing in an electric oven at 93-104°C (200-220°F), and carefully install it on the turbine shaft rear journal. Allow the bearing to cool; then apply MIL-L-6082, grade 1100, lubricant and install the bearing outerring.

e. Install the rear roller bearing spacer.

f. Install the tab lockwasher with the tab in the shaft keyway.

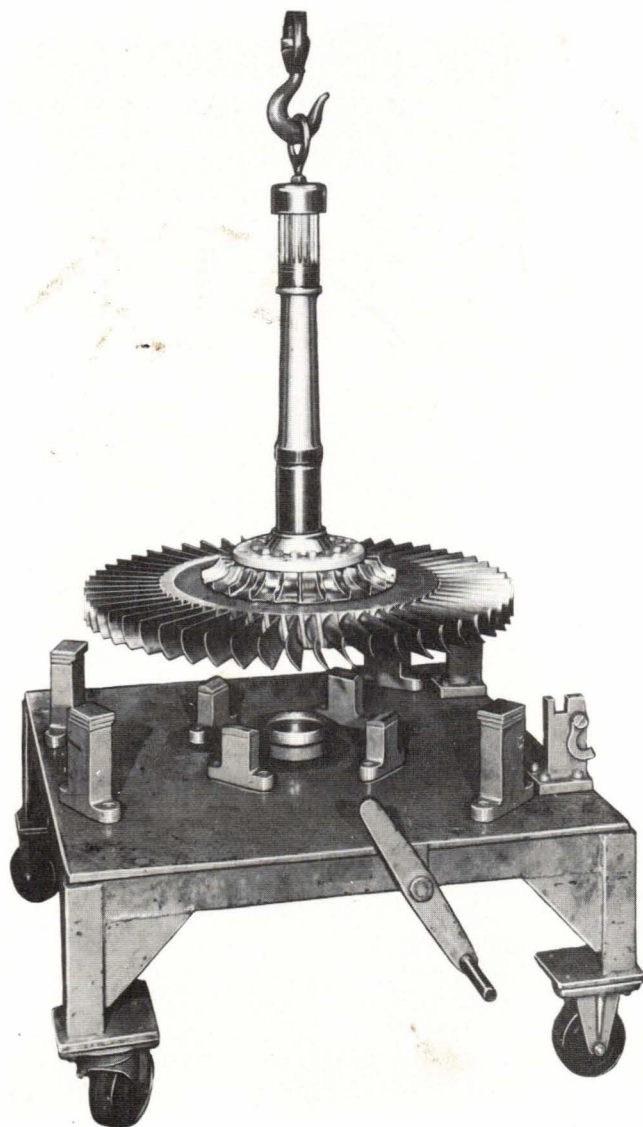


Figure 5-34. Installing the Turbine Rotor in Stand No. 2994 with Lifting Eye No. 2952

g. Apply Ab-lube to the washer contact surface and to the threads of the retaining nut. Install the nut, using the special wrench and the torque wrench. Tighten to the torque in paragraph 5-88. (See figure 5-35.)

CAUTION

Tightening the locknut may cause movement of the tab lockwasher, thus shearing the keyway tab. To inspect for proper position of the tab lockwasher after the locknut is tightened, clearly mark the washer outer tab, opposite the keyway tab, before installing the washer. If the lockwasher moves during locknut tightening, remove the nut and replace the lockwasher. Lubricate the nut-to-washer contact face to reduce friction.

h. Fasten the nut by bending over the lockwasher tabs. Bend over the free tabs against the nut with the special pliers.

i. Install the seal ring in the groove of the oil deflector.

5-88. TORQUE LIMITS.

Size	Name	Location	Torque
2 ¹⁵ / ₁₆ -12	Locknut	Turbine rear bearing	150-200 lb ft

5-89. TURBINE BEARING SUPPORT.

(Tool Group No. 17.)

a. With the bearing support on a work bench, install a new gasket and the scavenge tube on the scavenge outlet mounting boss at the bottom of the turbine bearing support. (See figure 5-24.) Secure with four bolts and washers.

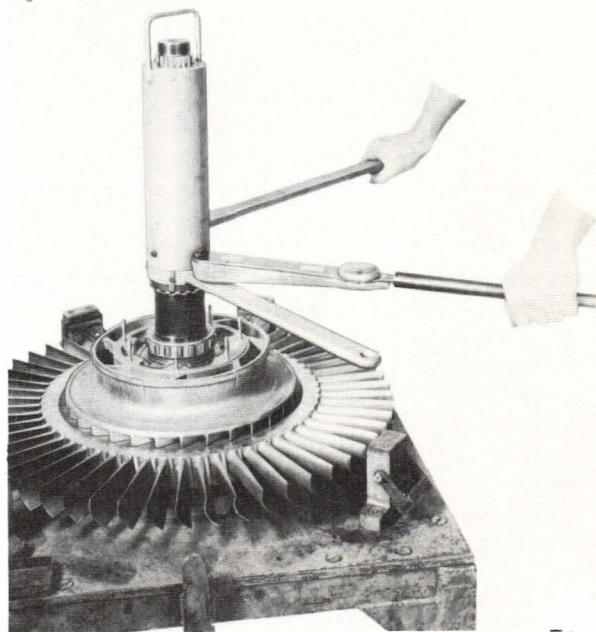
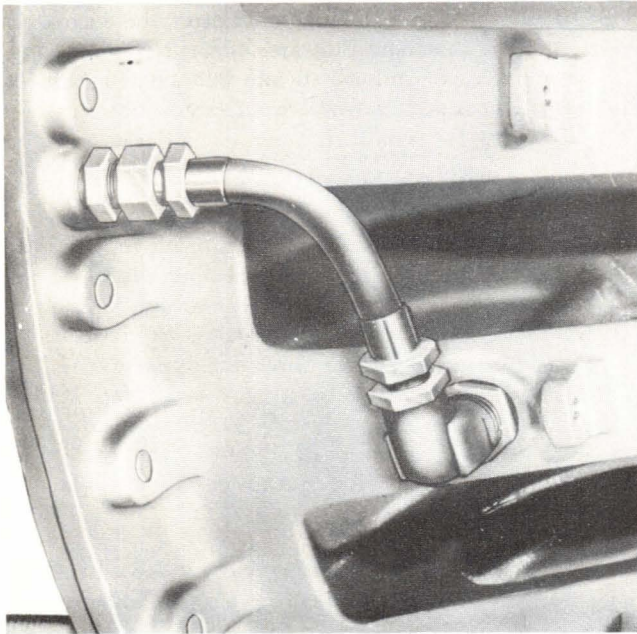


Figure 5-35. Installing the Turbine Rear Bearing Locknut with Wrench No. 3634

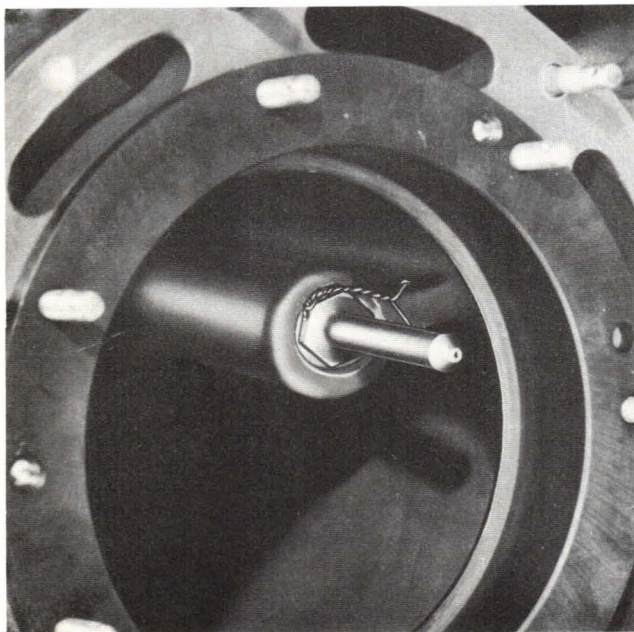


30039

Figure 5-36. Oil Pressure Line Installed

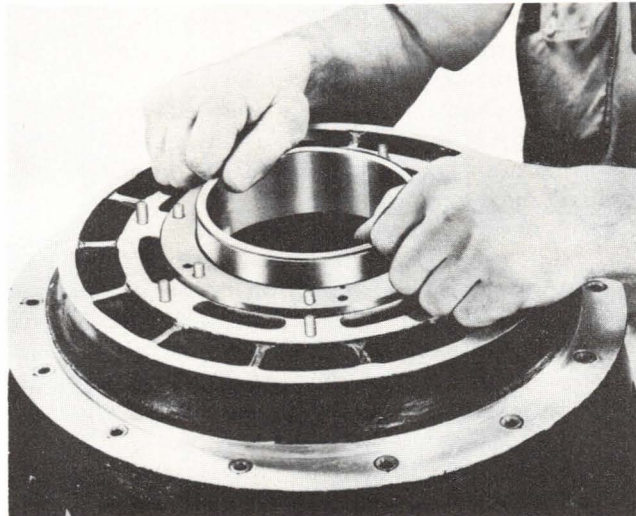
b. Install the union and gasket in the flange of the bearing support. Install the nut and gasket on the 90-degree oil inlet elbow. Install the elbow in the side of the support and tighten the coupling nuts. (See figure 5-36.)

c. Install the rear oil nozzle and filter with its gasket in the bearing support. Apply MIL-L-6082, grade 1100, oil to the nozzle thread. Safety the filter to the bearing support with lockwire. (See figure 5-37.)



32358

Figure 5-37. Turbine Rear Bearing Oil Nozzle



30318

Figure 5-38. Installing Turbine Rear Bearing Outer Ring

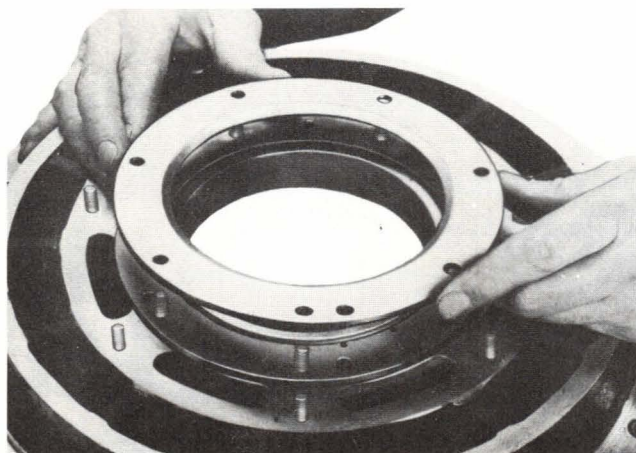
d. Install the turbine rear bearing cage. Tap the cage in place with a fiber drift if necessary. Install the bearing outer ring in the bearing cage with the numbered edge out. (See figure 5-38.) If the fit is tight tap in place with a fiber drift. Install the bearing retaining ring on the bearing cage and secure with seven slotted engine nuts. (See figure 5-39.)

e. Install the front and rear sections of the shroud over the bearing support and secure with 14 screws and washers. (See figure 5-23.)

f. Place the bearing support screen over the rear section of the bearing support shroud and align the attaching holes. (See figure 5-40.)

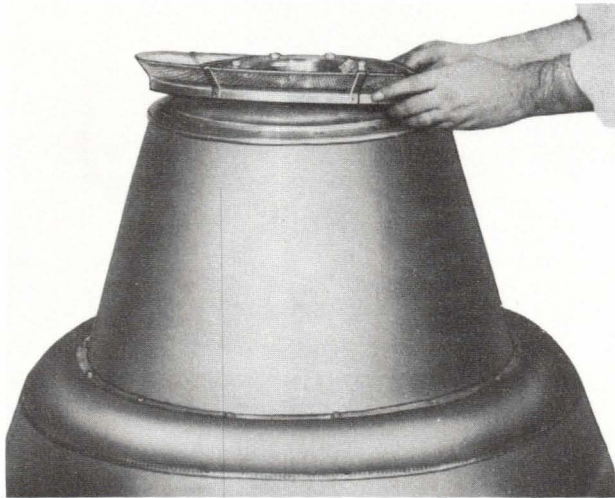
5-90. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{7}{16}$ -24	Slotted nuts	Turbine rear bearing housing retaining	40-60 lb in.
$\frac{1}{2}$ -20	Screen	Turbine rear oil nozzle	160-200 lb in.
$\frac{1}{2}$ -28	Nozzle	Turbine rear oil	125-150 lb in.



30173

Figure 5-39. Installing Turbine Rear Bearing Retaining Ring



30177

Figure 5-40. Installing Air Screen

5-91. RING AND TUBE. (Tool Group No. 17.)

- a. Place the ring and tube unit on a bench with the ring up.

CAUTION

Use extreme care in lowering the unit on the bench to prevent damage to the flanged ends of the tube.

- b. Position the lifting fixture from the stand on the ring and tube so that the lift points are aligned with No. 5 and No. 12 combustion chambers. Secure the fixture with eight through-bolts.
- c. Fasten the lifting yoke to the lifting fixture by inserting the pins in the ends of the yoke in the holes in the lifting fixture. (See figure 5-17.)
- d. Attach a hoist to the lifting yoke and place the ring and tube into the overhaul stand. Remove the hoist and lifting yoke. (See figure 5-18.) Turn the ring and tube to flight position in stand.

5-92. INNER CROSSOVER TUBES AND INNER LINERS. (Tool Group No. 9.) (Refer to paragraph 2-93.)

5-93. AIR BAFFLE.

- a. Fasten the outer air baffles to the combustion chamber flange with fourteen tie bars and twenty-eight bolts and self-locking nuts.
- b. Fasten the inner air baffle sectors at position No. 4 and No. 11 to the combustion chamber mounting flange with eight bolts. Temporarily fasten the remaining inner sectors with bolts.

Note

When it is necessary to replace air baffle sectors at positions No. 4 and 11 with a new part, position the new sector on the ring and tube. Mark

the attaching bolt hole centers on the sector from the mating flange holes of the tube. Remove the sector and drill four 0.260-0.250 inch diameter holes. New spare sectors do not have attaching holes drilled. Inner air baffles at position No. 3 and No. 10 do not require bolts; they are merely slipped into position on the combustion chamber flange.

5-94. TURBINE NOZZLE.

- a. Install the turbine nozzle with the attaching hole flange toward the front and align the attaching bolt holes.
- b. Install the nozzle baffle with the attaching hole flange toward the front and align the attaching bolt holes. (See figure 5-20.)
- c. Lightly coat the threads of the nozzle retaining bolts and the washers with MIL-C-5544 thread lubricant.

5-95. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{3}{16}$ -24	Bolts	Turbine nozzle to ring and tube	
		a. Tighten initially to approximately	75 lb in.
		b. Individually loosen each bolt and retighten to	90-125 lb in.
		c. Turbine nozzles that have been used must be tightened at least twice to obtain final measured torque of	90-125 lb in.

5-96. INSTALLING THE RING AND TUBE ON THE TURBINE BEARING SUPPORT. (Tool Group No. 17.)

- a. Rotate the ring and tube in the stand so that the turbine nozzle is up. With the lifting yoke on a hoist, attach the ends of the yoke to the fixture in the stand. Release the screw clamps and swing the unit free of the stand.
- b. Lower the ring and tube onto the turbine bearing support, aligning the oil transfer sleeve in the turbine bearing support with the recess in the rear compressor bearing support.
- c. Remove the lifting yoke and fixture. Install the ring and tube spacers, washers, and nuts on the mounting studs. Lubricate the stud threads with MIL-G-7187. (See figure 5-16.) Tighten the nuts. Safety with nuts and cotter pins.

5-97. TORQUE LIMITS.

Size	Name	Location	Torque
$\frac{7}{16}$ -20	Castellated nuts	Ring and tube to bearing support	
		a. Tighten to approximately	75 lb in.
		b. Loosen and retighten to	140-165 lb in.

5-98. TURBINE DIFFUSER.

(Tool Groups No. 16 and 17.)

- a. Place the cooling air diffuser on a bench with the vanes down.
- b. Place the new gasket on the oil seal mounting flange and install the oil seal with the channel flange up. (See figure 5-41.)
- c. Install the six washers and drilled fillister head retaining screws.

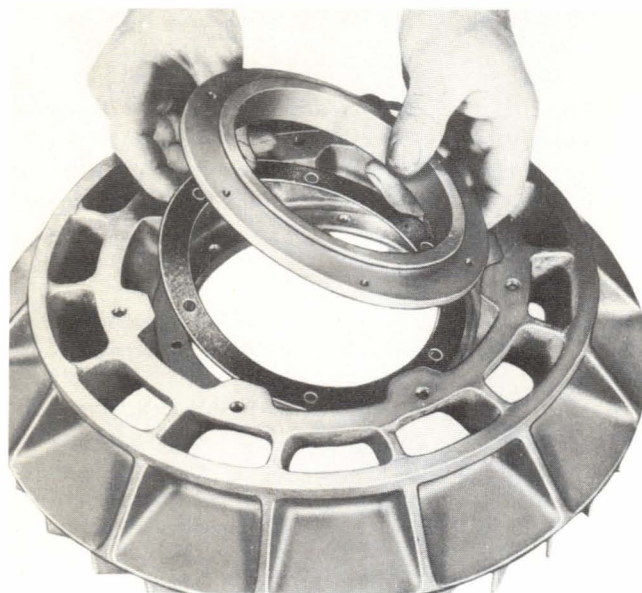


Figure 5-41. Installing Gasket and Oil Seal on Cooling Air Diffuser

30169

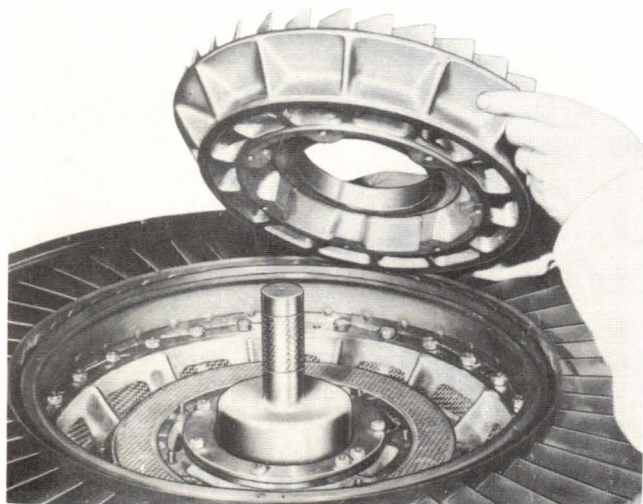
d. Install a new gasket on the rear face of the turbine bearing support. Install the diffuser screen in the groove in the bearing support.

e. Install the turbine bearing oil seal guide in the rear turbine bearing cage.

f. With the oil seal fixture in place, carefully install the cooling air diffuser and oil seal over the locating fixture onto the bearing support. Lubricate the fixture with MIL-L-6082, grade 1100, oil. (See figure 5-42.)

g. Fasten the diffuser with seven slotted nuts and washers. Remove the locating fixture.

5-99. Rotate the unit 180 degrees in the stand so that the front of the turbine support is accessible.



30168

Figure 5-42. Installing the Cooling Air Diffuser with Fixture No. 3145 or No. 2864

5-100. Install the special turbine shaft guide sleeve in the bearing support. (See figure 5-9.)

Note

The locating arm of the guide must enter the front turbine nozzle oil passage in the bearing support so that the guide will fit properly over the rear jet.

5-101. Place overhaul cover plates over the open ends of the combustion chambers to keep dirt out.

5-102. TORQUE LIMITS.

Size	Name	Location	Torque
1/4-28	Castellated nuts	Diffuser to bearing support	45-60 lb in.

5-103. INSTALLING THE RING AND TUBE ON THE TURBINE ROTOR.

(Tool Groups No. 16 and 17.)

a. Attach a sling and chain hoist to the mounting ring of the stand holding the turbine unit.

b. Loosen the hand screws securing the mounting ring to the stand. Remove the unit from the stand by lowering it slightly and slipping it out through the horseshoe opening.

c. Apply VV-P-236 to rear bearing rollers and lower the turbine unit onto the turbine rotor, carefully directing the shaft into the special guide in the bearing support. The No. 1 combustion chamber should line up between the trunnion supports. (See figure 5-43.)

d. Remove the nuts securing the mounting ring to the unit and remove the ring and shaft guide.

5-104. ASSEMBLING THE TURBINE FRONT BEARING CAGE. (Tool Group No. 17.)

Note

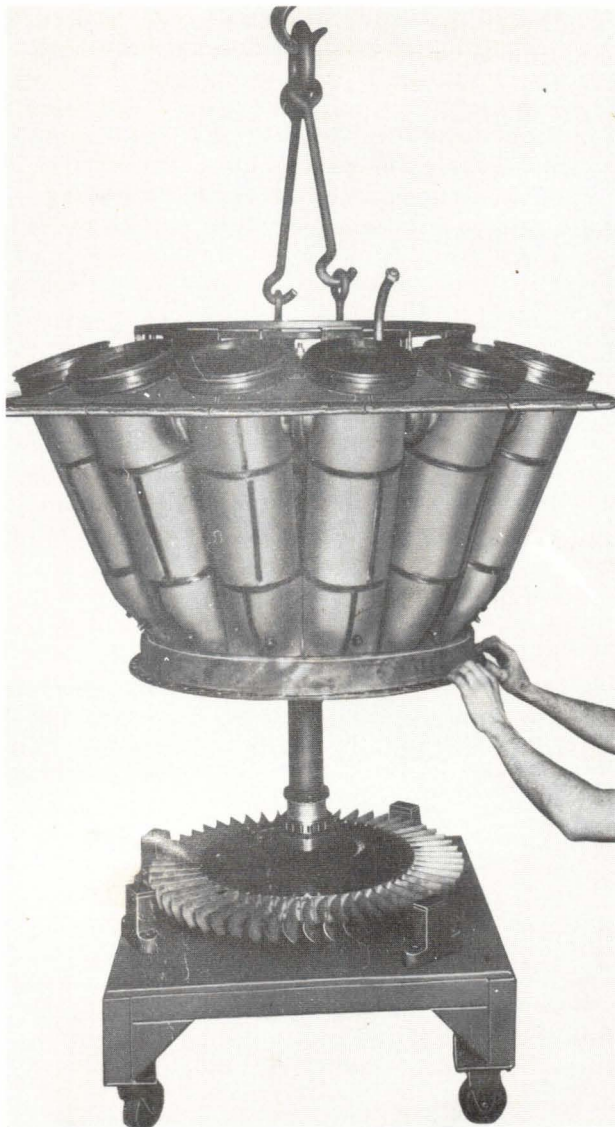
If the bearing being installed is the type with a two-piece inner ring, only the bearing outer ring will be installed in the cage and fastened by the retainer ring. Install the rear half of the bearing inner ring on the shaft, after installing the bearing shoulder ring. Install the bearing ball and cage unit as the bearing cage and outer ring assembly is being moved into position in the bearing support. Install the front half of the inner ring to complete the bearing assembly. The following steps are for the installation of a bearing with a one-piece inner ring.

a. Place the cage on a bench with the threaded end up. Insert the turbine front bearing in the ring with the 0-mark on the inner ring up.

b. Install the internal retaining ring.

c. Install the adjusting nut on the cage flush with the top.

d. Raise the turbine rotor with the screw jack on the stand until it barely touches the sealing baffle. One



39200

Figure 5-43. Lowering the Ring and Tube over the Turbine Shaft

person operates the jack while the other rotates the turbine shaft by hand until the rotor can be felt to bind slightly.

e. Install the turbine shaft forward bearing shoulder ring.

f. Install the turbine front bearing and cage over the turbine shaft. (See figure 5-44.) Use care to avoid cocking the assembly. Be sure the bearing is bottomed against the shoulder on the shaft. Use a mallet and a metal sleeve driver or a fiber drift on the bearing inner ring to install the bearing and cage.

5-105. TURBINE FRONT BEARING OIL NOZZLE.

a. Place a new gasket and the oil nozzle adapter with its filter on the turbine support oil nozzle mounting pad. (See figure 5-45.)



27715

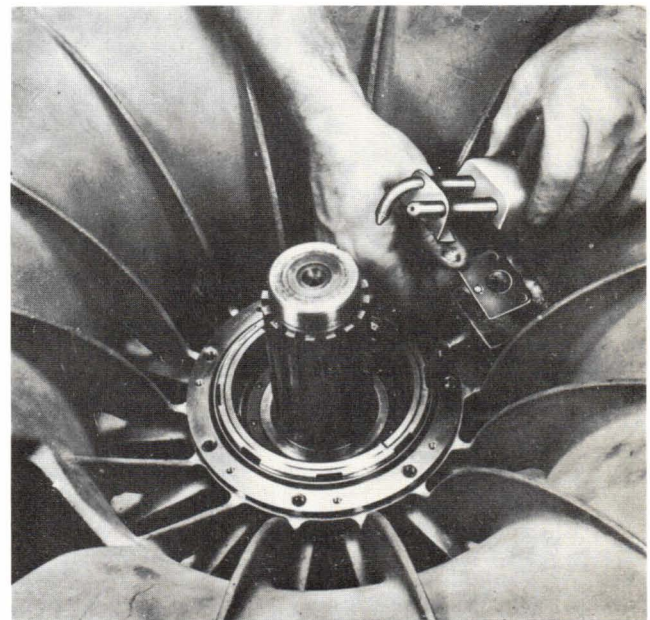
Figure 5-44. Installing the Turbine Front Bearing and Cage

b. Insert three special fillister head screws with washers in the oil nozzle block and tighten with fingers enough to hold the block in place.

5-106. TURBINE COUPLING.

(Tool Groups No. 12 and 17.)

a. Insert the turbine coupling hub into the rear splines of the coupling sleeve. Apply MIL-L-3572 before installation. Place the retainer washer over the hub, and install the retainer ring in the sleeve. (See figure 5-46.)



27758

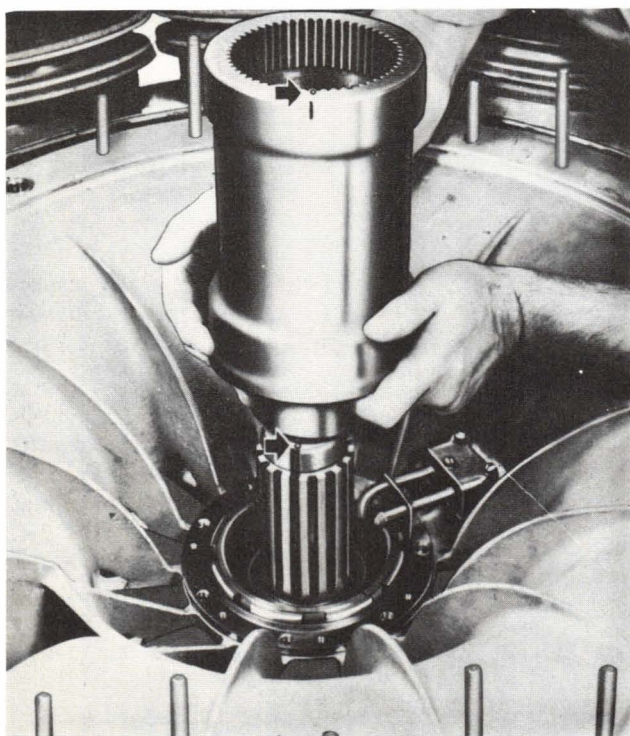
Figure 5-45. Installing the Turbine Front Bearing Oil Nozzle



42422

Figure 5-46. Installing the Coupling Sleeve Retaining Ring

b. Place these assembled parts over the turbine shaft. Match the two 0-marks. (See figure 5-47.) Apply Ab-lube to the washer contact surface and to the nut threads, and install the lockwasher and retaining nut on the shaft.



30328

Figure 5-47. Installing Turbine Coupling on Turbine Shaft

c. Insert the wrench and holder into the coupling sleeve, fitting the external splines of the holding fixture into the internal splines of the sleeve; fasten the tool to the bearing support with the sleeve nut. (See figure 5-5.) Tighten the nut. Bend the lockwasher tab into the nut with the pliers. (See figure 5-48.)

d. Lower the stand jack from the turbine wheel.

5-107. TORQUE LIMITS.

Size	Name	Location	Torque
2 1/8-16	Locknut	Turbine front bearing	150-200 lb ft

5-108. ADJUSTING CLEARANCE BETWEEN THE TURBINE WHEEL AND THE GAS BAFFLE. (Tool Group No. 8.)

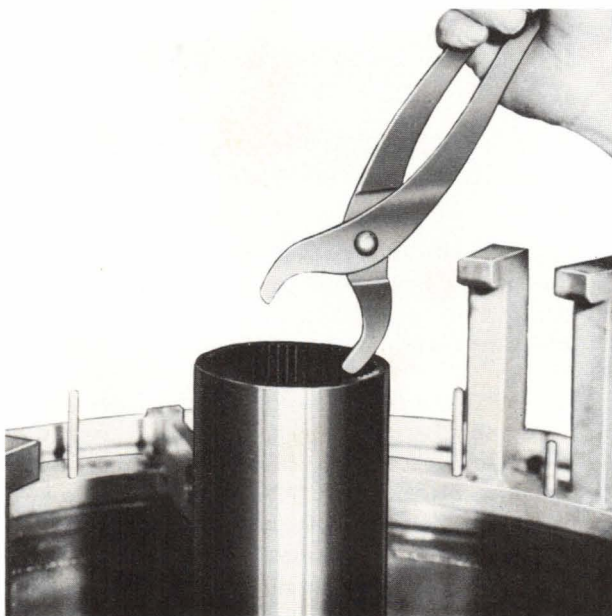
a. Place the plug in the end of the turbine shaft. Install the two indicator mounting bracket pins on the turbine bearing support so that when the dial indicator and bracket is attached, the indicator pick-up point will touch the center of the plug.

b. Install the indicator mounting bracket on the pins and secure with the two nuts provided.

c. Attach a dial indicator reading in thousandths to the bracket with a bolt and nut. (See figure 5-49.) Place the dial indicator point of contact in the center of the end of the plug. Tighten the gauge in the slotted hole in the attaching boss at a point which will allow adequate indication in either direction.

d. Recheck the position of the turbine rotor by rotating the shaft by hand and adjusting the screw jack on the stand until the rotor can be felt to bind slightly against the gas baffle. (See figure 5-50.) Set the dial at zero.

e. With the rotor supported by the jack, back off the adjusting nut on the bearing sliding ring until it is possible to lower the rotor with the jack approximately



42394

Figure 5-48. Lockwasher Pliers No. 3147

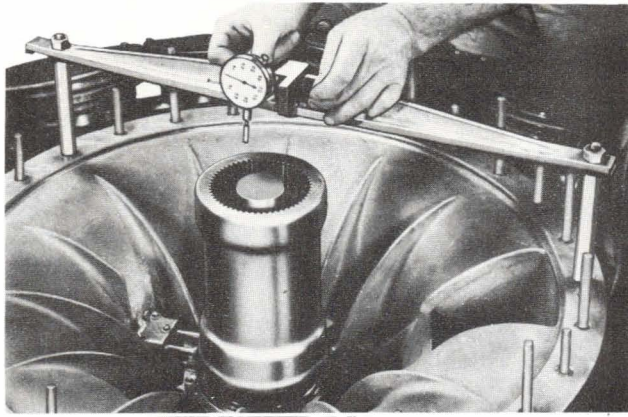


Figure 5-49. Attaching Dial Indicator to Bracket No. 2902

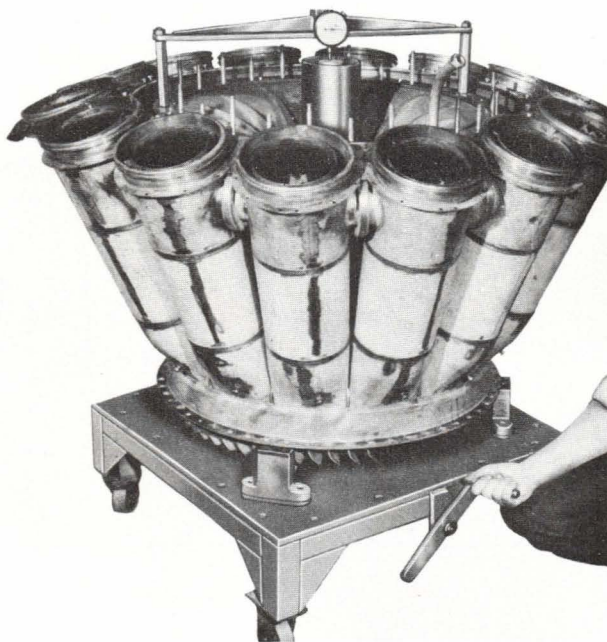


Figure 5-50. Raising Turbine Rotor to Adjust Clearance

0.160 inch as shown on the indicator. Then lower the rotor to the extent of its travel. (See figure 5-51.)

f. Raise the rotor again with the jack until the clearance as shown by the dial indicator is reduced to the minimum value given in paragraph 5-119.

g. Tighten the adjusting nut firmly by hand and align the retaining bolt holes with the nearest set of holes in the bearing support. To get these holes in alignment, it may be necessary to raise the turbine rotor slightly with the jack or to back the adjusting ring off slightly. In either case, the dial indication will be affected when the jack is removed.

h. Lower the jack from the turbine rotor.

i. Insert two of the bolts in the adjusting nut holes and tighten the bolts securely to prevent the nut from moving.

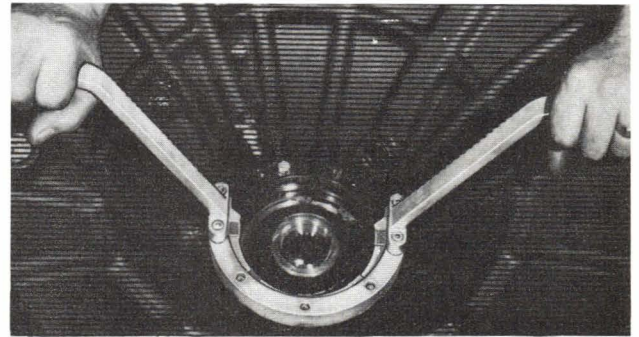


Figure 5-51. Sliding Ring Wrench No. 3614

j. To make the final adjustment of the turbine rotor-to-gas-baffle clearance, raise or lower the rotor slightly by turning the sliding ring with the special wrench. When the indicator shows the minimum allowable clearance again, align a castellation of the sliding ring with the nearest bolt hole in the adjusting nut so that the lock may be inserted.

Note

This clearance, given in paragraph 5-119, is based on the clearance measured with the weight of the turbine wheel hanging on the locating bearing. Limits specified include consideration of bearing clearance.

k. Insert the lock and retaining fillister-head screw into the sliding ring castellation and the adjusting nut hole which have been aligned.

l. Install the bolts in the adjusting nut and tighten them.

m. Tighten the three fillister-head screws which secure the oil nozzle adapter.

n. Remove the dial indicator, the mounting bracket, adapters, and plug.

o. Inspect and adjust the oil nozzle, using an inspection mirror. (See figure 5-52.) The jet orifice must be directed at the bearing rollers, and the oil line must not touch the coupling sleeve.

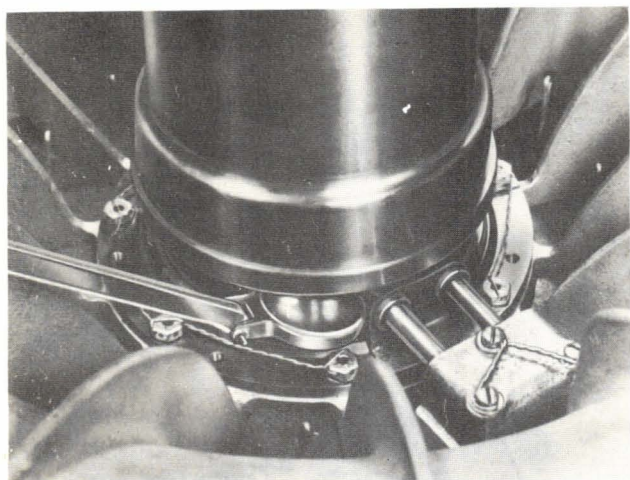
5-109. Install the turbine wheel shroud ring and check with a feeler gauge to see that blade tip clearance is within limits. (Refer to paragraph 5-119.) Install the insulation pad on the ring and tube at the rear flange and secure it with lockwire lacing as shown in figure 2-4.

5-110. TORQUE LIMITS.

Size	Name	Location	Torque
5/16-24	Locknut	Turbine shroud to ring and tube	90-110 lb in.

5-111. FINAL ASSEMBLY.

5-112. The following paragraphs contain information for final assembly of the engine. The sequence of assembly may be varied to meet local conditions.



26923

Figure 5-52. Inspecting Oil Nozzle Adjustment

5-113. INSTALLING THE TURBINE UNIT ON THE COMPRESSOR.

(Tool Group No. 17.)

a. Turn the turbine unit to a vertical position in the stand with the turbine wheel up. Install the lift sling on the turbine unit, and hook a hoist to the sling.

b. Lay a new gasket on the rear compressor bearing support, coating the flange with a very thin coat of soft VV-G-681 cup grease to hold the gasket in place for assembly.

c. Remove the six sleeve nuts securing the turbine unit to the mounting ring in the stand. Lift the unit from the stand and lower it onto the compressor, aligning the 0-mark on the compressor rotor hub with the 0-mark on the coupling sleeve. The shafts can be rotated by hand to accomplish this. Continue to lower the unit, aligning the No. 1 combustion chamber with the No. 1 diffuser outlet.

Note

Make certain that the oil transfer sleeve of the turbine bearing support properly enters the oil passage of the rear compressor bearing support.

d. Install the self-locking nuts and washers on the attaching studs at the inside of the vee braces of the rear truss ring.

e. Install a pair of burner ring tie straps on the remaining studs and secure with self-locking nuts. The other ends of the tie straps are secured to the tube flange in pairs with two bolts.

f. Tighten the compressor-to-turbine unit attaching nuts firmly. Tighten all compressor to turbine unit attaching nuts to the specified torque. Remove the turbine unit lifting fixture.

5-114. AIR ADAPTER. (Refer to paragraph 2-82.)

5-115. INSTALLING THE EXHAUST UNIT.

(Tool Group No. 14.)

a. Turn the engine to the horizontal position in the overhaul stand.

b. Install the exhaust unit so that the inner cone supporting vanes are in the vertical and horizontal plane through the axis of the cone with the thermocouple bosses located in the 2:30, 6:30, and 10:30 o'clock positions when looking at the engine from the rear.

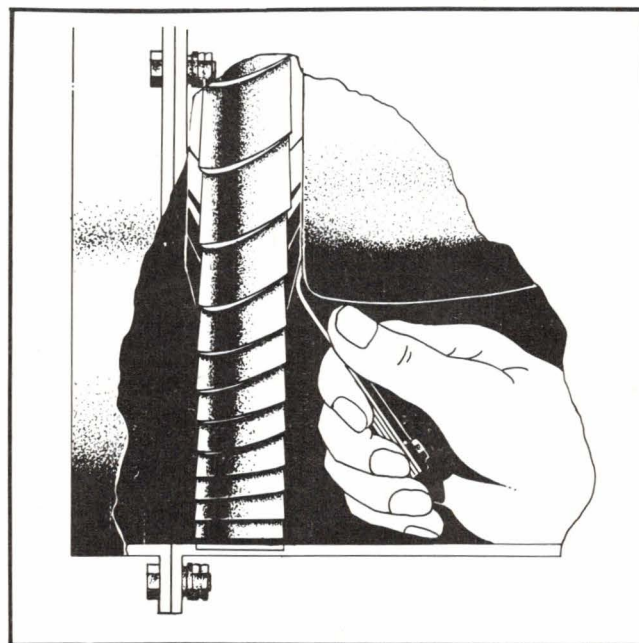
c. Lubricate the retaining bolts with MIL-C-554 lubricating compound, and install in the flange with the bolt heads toward the front of the engine.

d. Firmly tighten four equally-spaced bolts and make a preliminary measurement of the blade tip-to-flange-clearance with a feeler gauge. (Refer to paragraph 5-119.) The shroud ring may be shifted radially to equalize clearances. Measure the inner exhaust cone flange-to-turbine wheel clearance in four places at approximately 90° intervals with the feeler gauge. (Refer to paragraph 5-119 and figure 5-53.)

Note

If the exhaust cone fails to meet required limits, remove it and select another cone until clearances are within limits.

e. When clearances are within limits, tighten remaining bolts and nuts evenly. Then loosen one nut at a time and retighten finger-tight. Tighten nuts to the torque specified in paragraph 2-165. Make a final check of the blade-to-flange clearance and the inner cone-to-wheel clearance.



38168

Figure 5-53. Measuring Exhaust Cone Clearance

5-116. TORQUE LIMITS.

Size	Name	Location	Torque
5/16-24	Locknut	Inner cone clamping.....	160-240 lb in.
7/16-20	Locknut	Inner cone clamping.....	425-475 lb in.

5-117. THERMOCOUPLES AND HARNESS.

a. Install the thermocouple lead and harness. (Refer to paragraphs 2-272, 2-277, and 2-282.)

b. Attach the thermocouple lead to the receptacle mounting bracket.

c. Pull the lead to the rear through the hole in the air baffle. Install cable clamps. The exhaust unit forward attaching flange cable bracket is located at the 6th bolt to the right of the engine vertical centerline when viewing engine from the rear.

d. Install terminal block mounting brackets under the heads of the temporary bolts in No. 8, 16, 31, and 47 positions of the rear exhaust unit attaching flange. Attach the terminal blocks to the brackets. Install the cable clamp brackets under the heads of the temporary bolts in No. 24 and No. 39 positions.

Note

The bolt position is determined by numbering clockwise when viewing the engine from the rear. The top-center bolt hole is No. 1 position.

e. Install the thermocouples and connect leads to thermocouples and terminal blocks.

5-118. REMOVING THE ENGINE FROM THE OVERHAUL STAND. (Tool Group No. 4.)

a. Install the lifting bracket on the pad at the top of the diffuser.

b. Install lifting bracket on the two bosses located on the outer ring of the ring and tube.

c. Fasten the lifting sling to the two brackets and slip the hook of the chain hoist through the eye of the sling. Position the eye at the center of balance over the air adapters.

d. Put enough tension on the hoist chain to relieve the weight of the engine.

e. Remove the trunnion adapters lockpin and upper pillow blocks; then lift the engine from the overhaul stand.

f. Install the engine in the transportation stand. Remove the spherical adapter from the left-hand trunnion.

5-119. TABLE OF LIMITS.

5-120. The limits in paragraph 5-122 and 5-123 define the relationship between mating parts. Use them to supplement visual inspection when wear is suspected; and use them if there is difficulty in assembling the engine. Do not check each dimension as a routine part of disassembly or assembly.

5-121. Replace parts if the clearance exceeds the limits under the *R* column. If there is no dimension in this column, use the *minimum* and *maximum* columns. *T* means tight, and *L* means loose.

5-122. TURBINE UNIT CLEARANCE LIMITS. (See figure 5-54.)

	<i>Minimum</i>	<i>Maximum</i>	<i>Replace</i>
1. Turbine wheel blade tip clearance in the shroud			
Re-installed turbine wheel and shroud.....	0.0550		
New turbine wheel or new shroud.....	0.0650		
2. Ball bearing end play with 11-pound reverse load			
New Departure, Fafnir, or S.K.F.....		0.0110	0.0140
Marlin-Rockwell		0.0090	0.0140
3. Wheel-to-gas baffle clearance (with weight of turbine wheel toward rear on locating bearing)	0.1450	0.1550	
4. Position and fit of blades in the turbine wheel			
Tip movement in plane of rotation, before pinning.....	0.0100	0.0900	
Misalignment of wheel and forward side of the blade dovetail; blade moved full rear		±0.0100	
Misalignment of wheel and rear side of the blade dovetail; blade moved full rear		±0.0250	
Allowable fore and aft movement of pinned blade.....		0.0080	
5. Wheel-to-inner exhaust cone axial clearance.....	0.1250	0.3900	
6. Turbine front bearing on shaft (select)			
Part number 6726691 and 6726671.....	0.0004T	0.0002L	0.0005L
Part number 6748468 and 6748880.....	0.0003T	0.0009T	0.0000
7. Turbine front bearing sleeve in bearing support.....	0.0040T	0.0020T	
8. Turbine front bearing sliding ring in bearing sleeve.....	0.0003L	0.0020L	0.0030L
9. Turbine front bearing in sliding ring (select).....	0.0002L	0.0009L	0.0012L
10. Turbine rear bearing spacer on shaft.....	0.0005L	0.0025L	0.0050L
11. Turbine rear bearing on shaft (select).....	0.0004T	0.0002L	0.0005L
12. Turbine rear bearing oil slinger on shaft.....	0.0006L	0.0019L	0.0025L
13. Turbine rear bearing in bearing cage.....	0.0002L	0.0010L	0.0015L
14. Turbine ring and tube on turbine bearing support.....	0.0050L	0.0120L	0.0550L

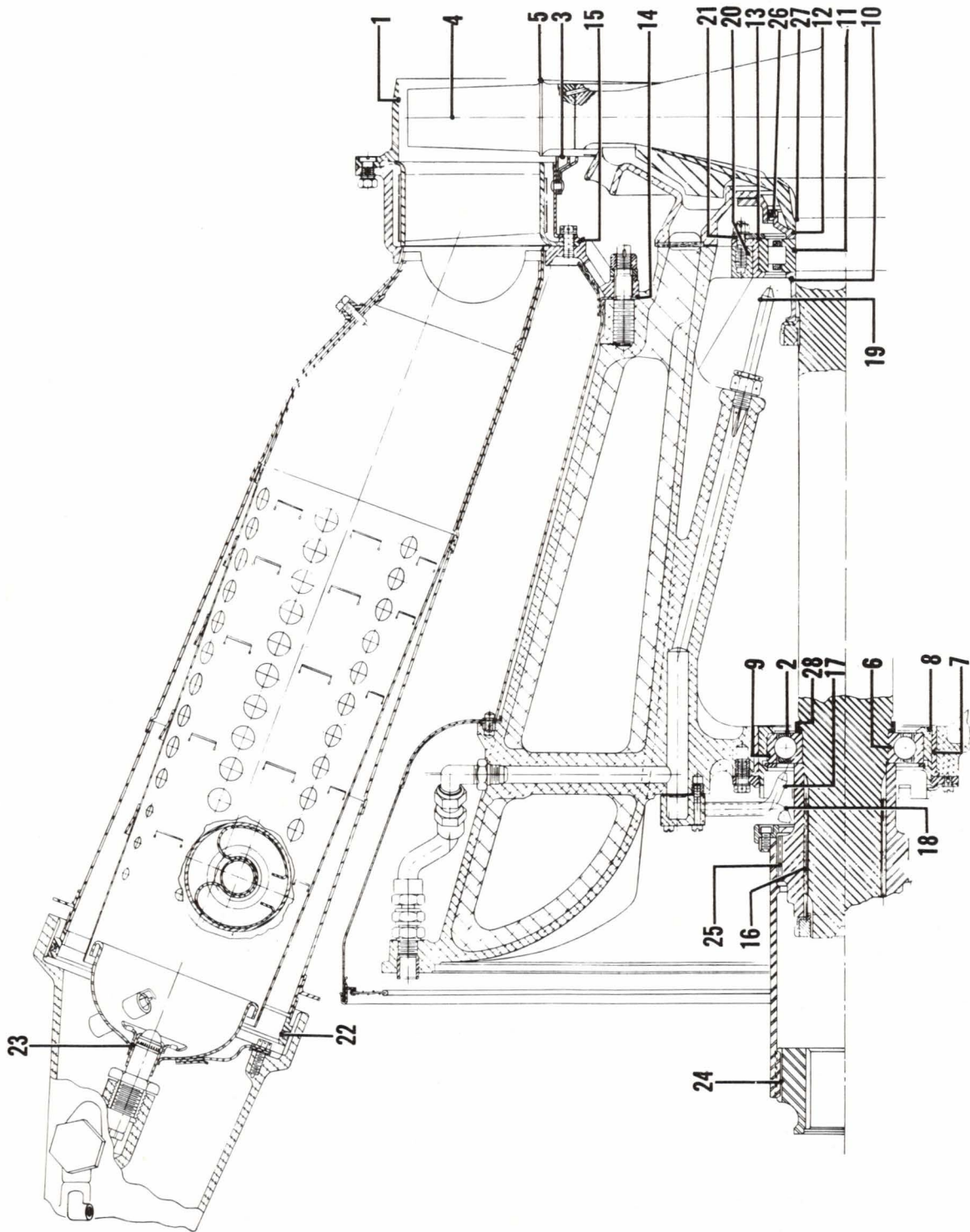


Figure 5-54. Turbine Unit Clearance Limits

5-122. TURBINE UNIT CLEARANCE LIMITS. (Cont)

	<i>Minimum</i>	<i>Maximum</i>	<i>Replace</i>
15. Turbine nozzle on ring and tube.....	0.0120L	0.0500L	0.1200L
16. Coupling hub spline on turbine shaft—tooth to tooth space clearance.....	0.0040L	0.0080L	0.0100L
17. Turbine front bearing oil nozzle orifice diameter.....	0.0510	0.0530	0.0540
18. Coupling oil nozzle orifice diameter.....	0.1000	0.1020	0.1030
19. Turbine rear bearing oil nozzle orifice diameter.....	0.0510	0.0530	0.0470 0.0570
20. Turbine rear bearing cage in bearing support.....	0.0020T	0.0000	L
21. Diffuser to turbine wheel rear bearing cage flange pilot diameter.....	0.0050L	0.0080L	
22. Piston rings in ring and tube side clearance.....	0.0080L	0.0140L	0.0160L
23. Fuel nozzle body to dome swirl sleeve.....	0.0010L	0.0050L	0.0070L
24. Compressor coupling hub in coupling sleeve (spline backlash).....	0.0084	0.0134	0.0145
25. Turbine coupling hub in coupling sleeve (spline backlash).....	0.0084	0.0134	0.0145
26. Seal ring in groove of oil deflector.....	0.0027L	0.0047L	0.0060L
27. Turbine cooling vane on shaft.....	0.0006L	0.0019L	0.0030L
28. Forward bearing shoulder ring on turbine shaft.....	0.0015T	0.0005L	L

5-123. EXHAUST UNIT CLEARANCE LIMITS. (See figure 5-55.)

1. Split ring and exhaust plate in cone flange side clearance.....	0.0050	0.0460	
2. Dowel tubes in inner cone.....	0.0030L	0.0090L	0.0150L
3. Dowel tubes in outer cone.....	0.0030L	0.0090L	0.0150L
4. Forward edge of inner cone flange to outer cone mounting face (axial).....	2.5070	2.5600	2.5850
5. Inner cone OD to be concentric with center line of outer cone mounting bolt circle within		$\frac{1}{16}$ T.I.R.	$\frac{3}{32}$ T.I.R.
6. Inner cone to strut spacer total diametrical clearance; minimum clearance must be at the bottom.....	$\frac{3}{64}$	$\frac{3}{32}$	$\frac{5}{32}$

5-124. TESTING.

5-125. After assembling the engine block-test it before preparing it for storage or installing it in an aircraft.

5-126. It is impossible to provide standard atmospheric conditions for testing, so remember to compare test data with performance charts which have been corrected for varying atmosphere.

5-127. LOG SHEET REQUIREMENTS.

5-128. Fill out the log sheet completely, accurately, and legibly.

a. Enter the name of the activity, the dates, the engine model, and the engine serial number.

b. Enter the jet nozzle diameter and area.

c. Enter the true barometer reading and the wet- and dry-bulb temperature reading. During erratic weather, take these readings every half hour or more often if necessary.

d. Besides the regular test data, enter unusual occurrences in the remarks column.

e. At the end of the test, enter the coastdown time, the time from the moment the throttle is closed until the engine stops rotating. If the time is unusually short, check for compressor rubbing.

f. The operator must sign the test log sheets; he is responsible for the data on them.

5-129. TEST REQUIREMENTS. (See table VIII)

5-130. Instruments for making these readings are necessary:

- Time of day.
- Engine rpm.
- Engine thrust in pounds.
- Fuel pump discharge pressure in pounds per square inch.
- Fuel manifold pressure in pounds per square inch.
- Oil pressure in pounds per square inch.
- Compressor inlet absolute pressure in inches of mercury.
- Exhaust gas temperature—the average and the range—in degrees Fahrenheit.
- Exhaust gas temperature spread.
- Compressor vibration.
- Turbine vibration.

5-131. TEST STAND INSTALLATION.
(Tool Group No. 5.)

5-132. After the engine has been installed in the test stand, make these connections:

- Make electrical connections to the tachometer generator, the control harness, the starter leads, the ignition cable, and thermocouple lead.

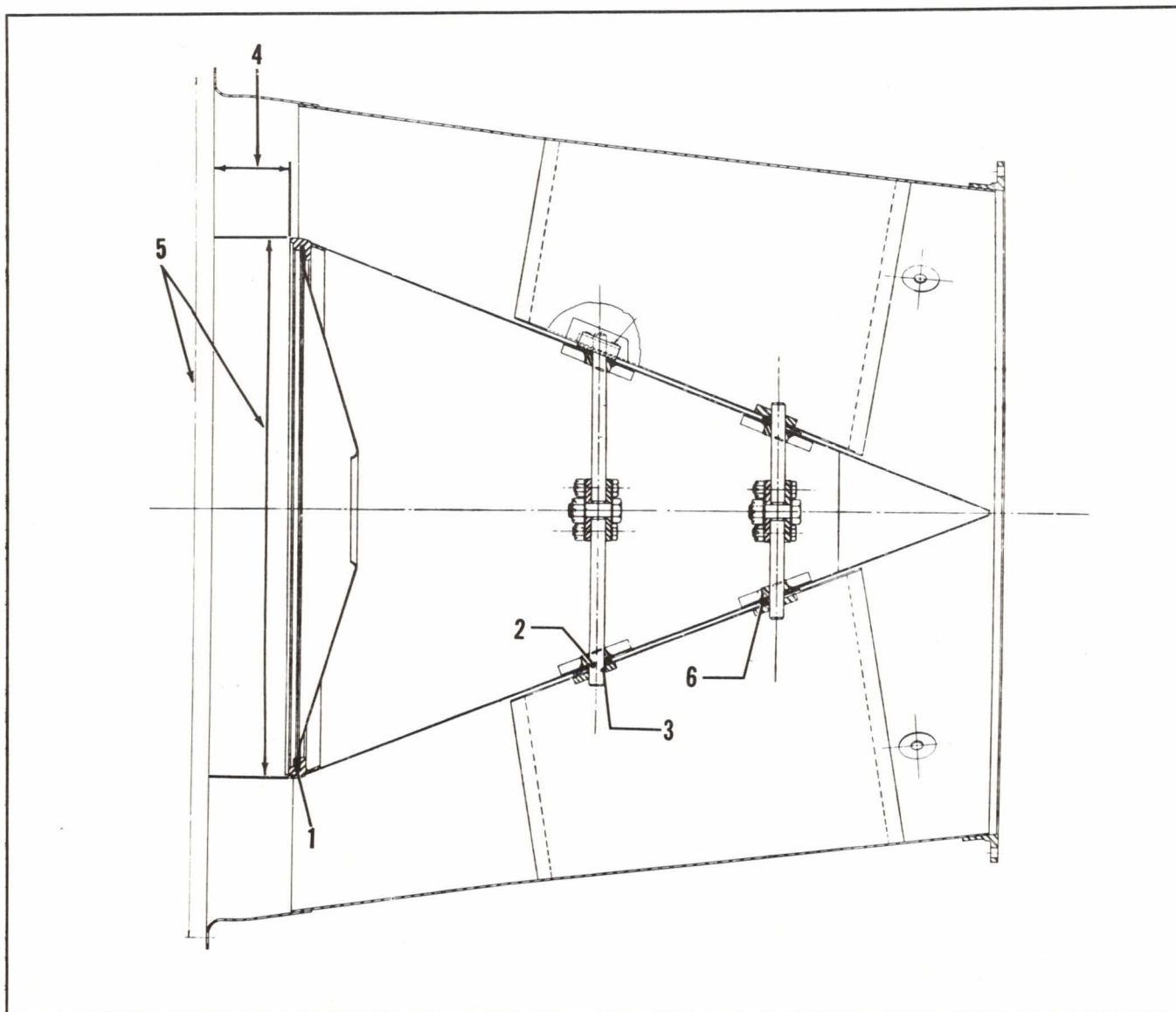


Figure 5-55. Exhaust Clearance Limits

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b. Connect the fuel inlet to the pump, and make connections to the fuel manifold drain and the accessories gear case vent.

c. Make pressure connections for the fuel pump, fuel manifold, and engine oil.

d. Install the test tail pipe and nozzle. (See figure 5-56.)

e. Connect tail pipe thermocouples and compressor inlet air thermocouples.

f. Install the throttle control rod.

g. Install turbine and compressor vibration pickups.

5-133. Before operating the engine in the stand, make these checks:

a. Fill the engine accessories case with 12 quarts of oil.

b. Make sure that the fuel control will be opened and closed by the throttle lever; mark the stand throttle for idle position.

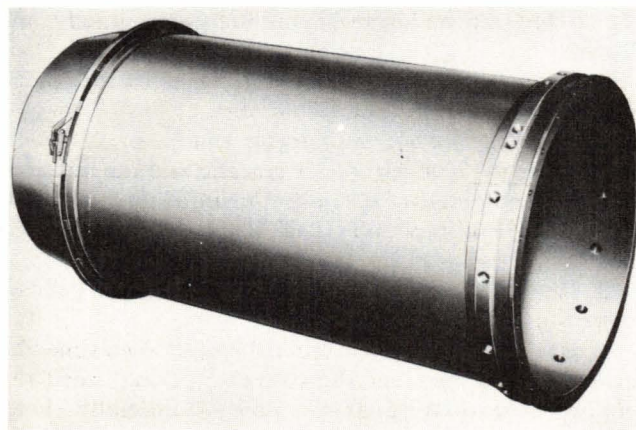


Figure 5-56. Engine Test Nozzle No. 3659

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- c. Check the security of the engine and the engine dolly.
- d. Check the freedom of the thrust cradle, and check the thrust manometer action and zero setting.
- e. Check the security of all instruments and connections.
- f. Make sure the floor is clean.

5-134. TEST PROCEDURES.**5-135. ENGINE STARTING.**

- a. Place the throttle in *CUTOFF*.
- b. Place the stand fuel valve *OPEN*.
- c. Place the master switch *ON*.
- d. Engage the starter and turn on the ignition switch.
- e. When engine speed reaches 1000 rpm place the starting switch in *AUTOMATIC*.
- f. A start is evidenced by an increase in exhaust temperature. If engine does not start within 3 seconds after fuel manifold pressure reaches 30 psi, place the starting switch *OFF*, disengage the starter, and check engine for trouble.
- g. When engine speed reaches 2000 rpm, disengage the starter and turn off the ignition switch.
- h. After the engine attains a speed of at least 3000 rpm on the starting fuel control, quickly open the fuel throttle to idle.

CAUTION

Do not creep or jockey the throttle. Move the starting switch to *OFF*.

- i. Do not operate the starter continuously for more than one minute.
- j. Engine speed must advance from 0 to 4000 rpm in 90 seconds or less.
- k. Allow at least 2½ minutes for fuel draining between starts.
- l. Do not engage the starter until it is cool enough to touch.

5-136. RECORDING TEST DATA.

5-137. See table IX for the test schedule. Refer to paragraph 5-143 for detailed instructions. Allow the engine to stabilize at each speed before recording data.

5-138. Compute and record this information:

- a. Actual thrust in pounds.
- b. Minimum allowable thrust in pounds.
- c. Thrust variation from the minimum allowable in percent.
- d. Maximum allowable average exhaust gas temperature in degrees Fahrenheit.
- e. Exhaust gas temperature variation from the maximum allowable in degrees Fahrenheit.

5-139. Record this data at engine starting:

- a. The time from engaging the starter to idle speed.

b. Maximum exhaust gas temperature on starting fuel control.

c. Maximum exhaust gas temperature on changeover to the main fuel control.

d. Speed at which the engine fires.

e. Maximum stabilized speed on the starting fuel control.

f. Manifold pressure on starting fuel control at stabilized speed.

5-140. Record this data during acceleration:

- a. The time from idle to 11,500 rpm.
- b. Maximum speed.
- c. Governed speed maximum setting.
- d. Recovery time.
- e. Fuel control operation.

5-141. SPEED CONTROL.

a. When taking thrust and exhaust gas temperature readings at top speeds, make sure that the stroboscope discs do not appear to be moving in either direction faster than one revolution per minute.

b. Correct for tachometer error the speeds read when operating at full throttle and when operating at idle before recording them in the log sheet.

c. Make an accurate check of the tachometer error when operating at 11,757 rpm. When the 31 disc slots appear stopped, read the tachometer carefully. The difference between this reading and 11,757 is the tachometer error for full-throttle operation.

5-142. GOVERNED SPEED OPERATION.

a. Governed speed is the average rotor speed maintained by the main fuel control at any speed setting. Fluctuation at any speed after stabilization must not exceed 60 rpm.

b. Make acceleration tests by opening the throttle from idle to full open in less than 1 second. Momentary large speed fluctuations may occur from the time the engine speed first reaches full throttle speed setting until it stabilizes at this speed. This is recovery time and should not exceed 5 seconds. The momentary speed fluctuations should not exceed ± 175 rpm. The maximum time for engine speed to reach 11,500 rpm is 15 seconds.

c. Make deceleration tests by moving the throttle from full-open to idle position in approximately one second.

5-143. PERFORMANCE EVALUATION.

5-144. Performance is evaluated by comparing the observed performance—corrected for observed conditions—with guaranteed values. Use table X to evaluate the engine:

a. Use table X to find the minimum allowable thrust for dry air corresponding to the observed compressor inlet temperature and barometric pressure.

b. Find the thrust vapor pressure correction, the top line of the table; subtract this correction from the result obtained in step a above to obtain the minimum allowable thrust. Record it on the log sheet.

TABLE VIII

Test Requirements		
Exhaust gas temperature:		
Idle rpm	149°C (300°F)	Maximum
Stabilized operating	93°C (200°F)	Maximum for speeds of 10,124 rpm and above (based on individual reading of 14 thermocouples in the thermocouple ring at the rear end of the tail cone)
Temperature during starting and acceleration	899°C (1650°F)	Maximum
Uncorrected exhaust gas temperature at any stabilized speed	716°C (1320°F)	Maximum
Fuel	MIL-F-5624, grade JP-4	
Lubrication	Preservative oil (Refer to paragraph 4-40)	
Oil pressure	7 psi at 8,440 rpm or above	Minimum
	55 psi at -17.8°C (0-30°F)	Maximum
	50 psi at 0.5-15.6°C (31-60°F)	Maximum
	45 psi over 15.6°C (60°F)	Maximum
Vibration	3 mils	Maximum for compressor or turbine during stabilized operation between 6000 and 11,800 rpm

c. From the actual thrust value, subtract the minimum allowable thrust and multiply the difference by 100; divide the result by the minimum allowable thrust value to obtain the percent variation from the minimum allowable thrust. Record this percent on the log sheet. The percent variation from minimum allowable thrust must be a plus value; if it is not, reject the engine.

d. Do not use the specific fuel consumption as a criterion for engine acceptability following repair.

e. Using the compressor inlet temperature correction table on the charts, locate the maximum allowable exhaust gas temperature; interpolate if necessary. This is

TABLE IX

Test Schedule					
Set- ting	Time minutes	Speed rpm	Disc slots	Read- ings	Remarks
1	5	4000±80 rpm	Tach.	1	Make visual inspection for oil, fuel, and air leaks, or other malfunctioning.
2		Accelerate from idle to full throttle			(Refer to 5-142.)
3	10	11,757	31	1	(Refer to 5-142.)
4		Decelerate to idle			(Refer to 5-142.)
5	1	4500±80 rpm	Tach.		Make visual inspection for oil, fuel, and air leaks, or other malfunctioning.
6		Shut down the engine			(Refer to 5-145.)

the maximum allowable exhaust gas temperature in dry air; it must be corrected for vapor pressure. Determine the exhaust gas temperature correction—at the top of the performance chart—corresponding to the vapor pressure established by the base weather station.

f. Subtract the correction value determined in step c above from the uncorrected maximum allowable exhaust gas temperature. This is the corrected maximum allowable exhaust gas temperature. If the actual exhaust gas temperature observed during the test is less than the corrected maximum exhaust gas temperature, the engine is acceptable.

5-145. ENGINE SHUTDOWN.

a. Operate engine at idle speed for at least 1 minute before shutting down, except in an emergency.

b. Shut down by closing the throttle.

c. When operating on the starting system, shut down by placing the starting switch *OFF*.

d. Turn the stand fuel valve *OFF* when the rotor stops turning.